PB83-105742

Regulatory Impact Analysis of the Use for PCB-Containing Electrical Equipment

Putnam, Hayes and Bartlett, Inc.
Cambridge, MA

Prepared for

Environmental Protection Agency
Washington, DC

Jul 82

U.S. Department of Commerce
National Technical Information Service
NTIS

PB83-105742

July 1982

REGULATORY IMPACT ANALYSIS OF THE USE RULE FOR PCB-CONTAINING ELECTRICAL EQUIPMENT

by

Charles J. Queenan III
Michael M. Schnitzer

Contract #68-01-5943
and
Task Order #2-15, Contract #68-01-6287

Amy Moll
Sammy K. Ng
Economics and Technology Division
Office of Toxic Substances
Washington, DC 20460

OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO. 560/4-82-004

2.

3. Recipient's Accession No. PB83 105742

4. Title and Subtitle
Regulatory Impact Analysis of the Use Rule
For PCB-Containing Electrical Equipment

5. Report Date
July, 1982

6.

7. Author(s)
Charles J. Queenan, III and Michael M. Schnitzer

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Putnam, Hayes, and Bartlett, Inc.
50 Church St.
Cambridge, MA 02138

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C) 68-01-5943
(G) 68-01-6287

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Toxic Substances
401 M Street, S.W.
Washington, D.C. 20460

13. Type of Report & Period Covered
Final Report

14.

15. Supplementary Notes
Project Officers: Amy Moll and Sammy Ng
This report updates and revises the Regulatory Impact Analysis for the proposed Electrical Equipment Rulemaking to incorporate new information and to reflect changes in the rule.

16. Abstract (Limit: 200 words)

On 12 February 1981, the U.S. Court of Appeals for the District of Columbia Circuit ordered EPA to conduct a rulemaking concerning the use of Polychlorinated Biphenyls (PCBs) in electrical equipment. EPA is now authorizing the use of PCBs in eight types of equipment. This Regulatory Impact Analysis was prepared to accompany the final rule.

For each equipment type, the base case is the case where the use of all PCB equipment is authorized indefinitely. Alternatives include equipment phase-outs of varying length, retrofilling, secondary containment, and inspection and maintenance programs to reduce spill volume and/or exposure. The benefits of alternative regulations are the avoided injury to health and environment that would otherwise have resulted from the incremental release of PCBs into the environment.

(continued on next page)

17. Document Analysis a. Descriptors
Polychlorinated Biphenyls Regulatory Impact Analysis
PCB Containing Electrical Equipment
Economic Impact Analysis

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement
Unlimited Availability

19. Security Class (This Report)
Unclassified

20. Security Class (This Page)
Unclassified

21. No. of Pages

22. Price

The major findings are: in the base case, approximately 2.2 million pounds of PCBs will be spilled; accelerated replacement dominates other alternatives selected by EPA; the cost-effectiveness of accelerated replacement varies dramatically among equipment categories; within categories, shorter replacement programs result in fewer spills and are nearly as cost-effective; and the economic impact of EPA's three mandated replacement programs on affected industries is very small and should not cause equipment manufacturing capacity to be exceeded.

This report was prepared under contract to an agency of the United States Government. Neither the United States Government nor any of its employees, contractors, subcontractors, or their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use or the results of such use of any information, apparatus, product, or process disclosed in this report, or represents that its use by such third party would not infringe on privately owned rights.

Publication of the data in this document does not signify that the contents necessarily reflect the joint or separate views and policies of each sponsoring agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

TABLE OF CONTENTS

Page

LIST OF TABLES. vi

EXECUTIVE SUMMARY xiii
- PCB Spills From PCB-Containing Electrical Equipment. xxii
- Cost-Effectiveness of Alternatives Within Equipment Categories xxiv
- Cost-Effectiveness of Alternatives Among Equipment Categories. xxiv
- Cost-Effectiveness of Alternative Phase-Out Periods xxvi
- Constraints Which Affect the Selection of Phase-Out Duration. xxviii
- Economic Impact on Affected Industries xxx

Chapter 1

INTRODUCTION. 1

Chapter 2

CONSIDERING ALTERNATIVE APPROACHES. 5
- PCB Capacitors 11
  - Nonsubstation Outdoor PCB Capacitors. . . .11
  - PCB Capacitors Located in Substations or Restricted Areas 12
  - PCB Capacitors Located Indoors or in Enclosed Areas 13

        PCB Capacitors Posing an Exposure Risk to Food or Feed 14
    Askarel Transformers 15
        Utility-Owned Askarel Transformers. . . .16
        Nonutility-Owned Askarel Transformers . .17
        Askarel Transformers Posing an Exposure Risk to Food or Feed 18
    Mineral Oil Transformers 19
    Electromagnets, Voltage Regulators, and Switches (Including Sectionalizers and Motor Starters) 20
    Circuit Breakers, Cables, and Reclosers. . . .21

Chapter 3

ASSESSING COSTS .22
    PCB Capacitors 25
        Nonsubstation Outdoor PCB Capacitors. . .25
        PCB Capacitors in Substations or Restricted Areas 28
        PCB Capacitors Located Indoors or in Enclosed Areas 30
        PCB Capacitors Posing an Exposure Risk to Food or Feed 32
    Askarel Transformers 32
        Utility-Owned Askarel Transformers. . . .32
        Nonutility-Owned Askarel Transformers . .34
        Askarel Transformers Posing an Exposure Risk to Food or Feed 36
    Mineral Oil Transformers 38
        Utility-Owned PCB and PCB-Contaminated Mineral Oil Transformers 38
    Other PCB-Containing Mineral Oil Equipment 41

Chapter 4

ASSESSING BENEFITS. 42
    PCB Capacitors 44
        Nonsubstation Outdoor PCB Capacitors. . .44
        PCB Capacitors Located in Substations or Restricted Areas 44
        PCB Capacitors Located Indoors or in Enclosed Areas 47
        PCB Capacitors Posing an Exposure Risk to Food or Feed 49
    Askarel Transformers 49
        Utility-Owned Askarel Transformers. . . .49
        Nonutility-Owned Askarel Transformers . .52
        Askarel Transformers Posing an Exposure Risk to Food or Feed 52

Mineral Oil Transformers 55
Utility-Owned PCB and PCB-Contaminated Mineral Oil Transformers 55
Other PCB-Containing Mineral Oil Equipment . .57

Chapter 5
EVALUATING COSTS AND BENEFITS 58
PCB Capacitors 60
Nonsubstation Outdoor PCB Capacitors. . .60
PCB Capacitors in Substations or Restricted Areas 70
PCB Capacitors Located Indoors or in Enclosed Areas 73
PCB Capacitors Posing an Exposure Risk to Food or Feed 73
Askarel Transformers 73
Utility-Owned Askarel Transformers. . . .73
Nonutility-Owned Askarel Transformers . .80
Askarel Transformers Posing an Exposure Risk to Food or Feed 83
Mineral Oil Transformers 91
Utility-Owned Mineral Oil Filled Transformers 91
Other PCB-Containing Mineral Oil Equipment . .94

Chapter 6
ASSESSMENT OF PCB DISPOSAL AND CAPACITOR MANUFACTURING CAPACITY REQUIRED TO ACCOMMODATE MANDATED PHASE-OUTS 95
PCB Disposal Capacity. 96
Capacitor Manufacturing Capacity 98
Summary. 101

Chapter 7
DISTRIBUTIONAL EFFECTS. 102
Nonsubstation Outdoor PCB Capacitors 103
Allocation Procedure. 105
Comparison of Phase-Out Costs to Net Investment in Electric Plant 107
Comparison of Phase-Out Cash Cost to Growth in Net Investment 107
Comparison of Revenue Requirements Increases With 1979 Revenue Requirements 113
Capacitors and Askarel Transformers Posing an Exposure Risk to Food and Feed. 115
Allocation Procedure. 116

Comparison of Net Phase-Out Costs With Food and Feed Industry Assets. 116
Comparison of 1984-1988 Phase-Out Cash Costs With Internal Cash Flow. 121

REFERENCES. 126

Appendix A
PROCEDURE FOR ANALYSIS OF ALTERNATIVE NEW RULES REGULATING THE USE OF PCBS IN ELECTRICAL EQUIPMENT. A-1

LIST OF TABLES

Page

Table S-1. PCB-Containing Electrical Equipment. . . . xvi

Table S-2. Summary of Alternatives Analyzed xviii

Table S-3. Estimated PCB Spills, by Equipment Category, for Indefinite Use Authorization. xxiii

Table S-4. Cost-Effectiveness of Retrofill and Secondary Containment Relative to 10-Year Phase-Out for Each Equipment Category. xxv

Table S-5. Cost-Effectiveness of Other Phase-Out Periods as a Percentage of the 10-Year Phase-Out Cost-Effectiveness xxvii

Table S-6. Cost-Effectiveness of Other Phase-Out Periods as a Percentage of the 10-Year Phase-Out Cost-Effectiveness xxix

Table 1. PCB-Containing Electrical Equipment. . . . 7

Table 2. Summary of Alternatives Analyzed 9

Table 3. 1982 Present Value Cost of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors 27

LIST OF TABLES (Continued)

Page

Table 4. 1982 Present Value Cost of Alternative PCB Regulations for PCB Capacitors Located in Substations or Restricted Areas. 29

Table 5. 1982 Present Value Cost of Alternative PCB Use Authorization for PCB Capacitors Located Indoors or in Enclosed Areas (Excluding Capacitors Posing an Exposure Risk to Food or Feed). 31

Table 6. 1982 Present Value Cost of Alternative PCB Use Authorizations for PCB Capacitors Posing an Exposure Risk to Food or Feed 33

Table 7. 1982 Present Value Cost of Alternative Regulations for Utility-Owned Askarel Transformers 35

Table 8. 1982 Present Value Cost of Alternative Regulations for Nonutility-Owned Askarel Transformers (Excluding Those Posing an Exposure Risk to Food or Feed) 37

Table 9. 1982 Present Value Cost of Alternative Regulations for Askarel Transformers Posing an Exposure Risk to Food or Feed 39

Table 10. 1982 Present Value Cost of Alternative Regulations for Utility-Owned Mineral Oil Filled Transformers Containing More Than 50 ppm PCB. 40

Table 11. Total Cumulative Weight of PCBs Spilled or Leaked from Nonsubstation Outdoor PCB Capacitors Under Alternative Regulatory Options. 45

Table 12. Total Cumulative Weight of PCBs Spilled or Leaked from PCB Capacitors Located in Substations or Restricted Areas Under Alternative Regulatory Options 46

LIST OF TABLES (Continued)

Page

Table 13. Total Cumulatie Weight of PCBs Spilled or Leaked from PCB Capacitors Located Indoors or in Enclosed Areas Under Alternative Regulatory Options 48

Table 14. Total Cumulative Weight of PCBs Spilled or Leaked from PCB Capacitors Posing an Exposure Risk to Food or Feed Under Alternative Regulatory Options 50

Table 15. Total Cumulative Weight of PCBs Spilled or Leaked from Utility-Owned Askarel Transformers Under Alternative Regulatory Options . . . 51

Table 16. Total Cumulative Weight of PCBs Spilled or Leaked from Nonutility-Owned Askarel Transformers (Excluding Units Posing an Exposure Risk to Food or Feed) Under Alternative Regulatory Options 53

Table 17. Total Cumulative Weight of PCBs Spilled or Leaked from Askarel Transformers Posing an Exposure Risk to Food or Feed Under Alternative Regulatory Options 54

Table 18. Total Cumulative Weight of PCBs Spilled or Leaked from Utility-Owned PCB and PCB-Contaminated Mineral Oil Transformers Under Alternative Regulatory Options 56

Table 19. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors 61

Table 20. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors 62

Table 21. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors 63

LIST OF TABLES (Continued)

Page

Table 22. Sensitivity Analysis -- Equipment Life: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with No Mandatory Inspection. 65

Table 23. Sensitivity Analysis -- Capacitor Price Escalation: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with No Mandatory Inspection 66

Table 24. Sensitivity Analysis -- Clean-Up Cost per Spill: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with No Mandatory Inspection 67

Table 25. Sensitivity Analysis -- Real Discount Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with No Mandatory Inspection. 68

Table 26. Sensitivity Analysis -- Failure Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with No Mandatory Inspection. 69

Table 27. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors in Substations or Restricted Areas 71

Table 28. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors in Substations or Restricted Areas 72

Table 29. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors Located Indoors or in Enclosed Areas (Excluding Capacitors Posing an Exposure Risk to Food or Feed) 74

LIST OF TABLES (Continued)

Page

Table 30. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors Located Indoors or in Enclosed Areas (Excluding Capacitors Posing an Exposure Risk to Food or Feed) 75

Table 31. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors Posing an Exposure Risk to Food or Feed. 76

Table 32. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors Posing an Exposure Risk to Food or Feed. 77

Table 33. Cost-Effectiveness of Alternative PCB Use Authorizations for Utility-Owned Askarel Transformers. 78

Table 34. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonutility-Owned Askarel Transformers. 79

Table 35. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonutility-Owned Askarel Transformers (Excluding Transformers Posing an Exposure Risk to Food or Feed) 81

Table 36. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonutility-Owned Askarel Transformers (Excluding Transformers Posing an Exposure Risk to Food or Feed) 82

Table 37. Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed . 84

Table 38. Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed . 85

LIST OF TABLES (Continued)

Page

Table 39. Sensitivity Analysis -- Equipment Life: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection. . 86

Table 40. Sensitivity Analysis -- Transformer Price Escalation Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection 87

Table 41. Sensitivity Analysis -- Clean-Up Cost per Spill: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection 88

Table 42. Sensitivity Analysis -- Discount Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection. . 89

Table 43. Sensitivity Analysis -- Failure Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection. . 90

Table 44. Cost-Effectiveness of Alternative PCB Use Authorizations for Utility-Owned Mineral Oil Filled Transformers Containing More than 50 ppm PCB. 92

Table 45. Cost-Effectiveness of Alternative PCB Use Authorizations for Utility-Owned Mineral Oil Filled Transformers Containing More than 50 ppm PCB. 93

LIST OF TABLES (Continued)

Page

Table 46. Required PCB Disposal Over the 5-Year Period, 1983-1987 97

Table 47. Large PCB Power Capacitors Retired Between 1982 and 1987 99

Table 48. Allocation of Pole-Top Distribution Capacitors. 106

Table 49. Comparison of Phase-Out Costs to Net Investment in Electric Plant. 108

Table 50. Incremental Cash Costs Associated with Distribution Capacitor Phase-Out. 110

Table 51. Total Increase in Capitalized Costs as a Percentage of Net Investment. 111

Table 52. Total Income in Capitalized Costs as a Percentage of Growth in Electric Plant Investment. 112

Table 53. Maximum Revenue Impact of Distribution Capacitor Phase-Out 114

Table 54. Distribution of Equipment Posing an Exposure Risk to Food or Feed 117

Table 55. Food and Feed Phase-Out Costs by Equipment Type and as a Percentage of Assets. . . .119

Table 56. 1984-1988 Phase-Out Cash Costs. 122

Table 57. 1984-1988 Food and Feed Phase-Out Costs as a Percentage of 1979 Estimated Cash Flow 123

EXECUTIVE SUMMARY

On 12 February 1981, the U.S. Court of Appeals for the District of Columbia Circuit issued an order requiring EPA to conduct a rulemaking concerning the use of PCBs in electrical equipment. The court also has ordered EPA to complete this new rulemaking by 19 August 1982. In response to the court's order, EPA is amending the existing PCB rule to allow the continued use of PCBs in eight different categories of electrical equipment. EPA is authorizing, pursuant to section 6(e)(2)(B) of the Toxic Substances Control Act (TSCA), the use of PCBs in:

1. Capacitors
    - -- PCB capacitors posing exposure risk to food or feed: through 1988;
    - -- PCB capacitors within restricted access electrical substations or in contained and restricted access indoor locations: indefinitely;
    - -- All other PCB capacitors: through 1988;
2. Transformers*
    - -- PCB transformers posing exposure risk to food or feed: through 1985 subject to weekly inspection and maintenance;
    - -- All other PCB transformers: indefinitely subject to quarterly inspection and maintenance;
    - -- All PCB-contaminated transformers: indefinitely;

---

* Excluding railroad transformers.

3. Electromagnets

    - PCB electromagnets posing an exposure risk to food or feed: through 1985 subject to weekly inspection and maintenance;

    - All other electromagnets: indefinitely;

4. Voltage regulators: indefinitely;

5. Cables: indefinitely;

6. Switches (including sectionalizers and motor starters): indefinitely;

7. Circuit breakers: indefinitely;

8. Reclosers: indefinitely.

While EPA does not believe that the proposed rule is a major rule as defined in section 1.b of Executive Order 12291, this Regulatory Impact Analysis (RIA) has nonetheless been prepared addressing, to the extent possible, the requirements set out in E.O. 12291.

For the purposes of this regulatory impact analysis, the eight types of authorized PCB-containing electrical equipment were reclassified into five categories:

1. PCB capacitors

    - Nonsubstation outdoor PCB capacitors;

    - PCB capacitors located in substations or in restricted areas;

    - PCB capacitors located indoors or in enclosed areas;

    - PCB capacitors posing an exposure risk to food or feed;

2. Askarel transformers*

    - Utility-owned askarel transformers;

---

* Nonrailroad transformers only.

    - Nonutility-owned askarel transformers;
    - Askarel transformers posing an exposure risk to food or feed;

3. Mineral oil transformers;
4. Oil-filled electromagnets, mineral oil voltage regulators, oil-filled cables, and mineral oil switches (including sectionalizers and motor starters); and
5. Mineral oil circuit breakers and mineral oil reclosers.

As Table S-1 shows, the first two categories, PCB capacitors and askarel transformers, account for 99.91 percent of the total PCBs.* The third category, mineral oil transformers, accounts for essentially all of the remaining 0.09 percent of the PCBs. The six other equipment types were split into two groups, roughly according to their average level of PCB contamination.

Within each classification, the base case is the case where the use of all PCB-containing electrical equipment is authorized indefinitely. Alternatives to the base case include equipment phase-outs of varying length, retrofilling (where technically feasible), secondary containment (where technically feasible), and inspection and maintenance programs to reduce spill volume and/or exposure. The alternatives analyzed for each of the five equipment classifications are summarized in Table S-2. Due to time constraints, the last two equipment categories received a limited, qualitative assessment.

The benefits of these alternative regulations are the avoided injury to health and environment that would

---

* These estimates do not account for PCBs in small capacitors used for high intensity discharge applications, in fluorescent lighting ballast, and in small appliances. These capacitors were estimated to contain 180 million pounds of PCBs in 1976 (Versar, 1977, pp. 1-5, 1-6). It is unclear how many of these capacitors still remain in service; moreover, EPA has not identified any cost-effective means of regulating their use.

Table S-1. PCB-Containing Electrical Equipment

Equipment Type	Number of Units	Total Fluid Volume (Gallons)	Total Pounds PCBs	Average PCB Concentration
PCB Capacitors				
Nonsubstation outdoor	1,232,000	3,326,000	38,595,000	100%
Located in substations or restricted areas	1,568,000	4,234,000	49,121,000	100%
Located indoors or in enclosed areas	490,000	979,000	11,360,000	100%
Posing exposure risk to food or feed	4,500	9,000	106,000	100%
	3,294,000	8,548,000	99,182,000	
Askarel Transformers				
Utility-owned	39,600	8,525,000	74,597,000	70%
Nonutility-owned	91,600	22,899,000	200,370,000	70%
Posing an exposure risk to food or feed	900	232,000	2,030,000	70%
	132,100	31,656,000	276,997,000	
Mineral Oil[a] Transformers	25,284,000	1,197,957,500	328,000	36 ppm
Electromagnets[b]	7,700	770,000	300[c]	50 ppm[c]
Voltage Regulators[d]	170,600	20,989,000	8,200	49 ppm

Table S-1. PCB-Containing Electrical Equipment (Continued)

Equipment Type	Number of Units	Total Fluid Volume (Gallons)	Total Pounds PCBs	Average PCB Concentration
Motor Starters	N.A.	N.A.	N.A.	10 ppm[e]
Switches/ Sectionalizers[f]	386,000	1,416,000	300	31 ppm
Cable[d]	7,700 miles	35,800,000	2,700[g]	10 ppm[g]
Circuit Breakers[d]	213,000	161,570,000	15,000	12 ppm
Reclosers[d]	200,000	4,005,000	500	16 ppm
	29,687,900+ 7,700 miles	1,462,711,500	376,534,000	

SOURCE: EEI/USWAG study (1982, pp. 9, 10, 109, A-14, A-15). Average concentration calculated by Putnam, Hayes & Bartlett, Inc. from EEI data, except where cited.

[a] Assuming utility ownership is 80 percent of total (EPA, 1982).

[b] Assuming utility ownership is 1 percent of total (EPA, 1982).

[c] Assuming from EEI (1982, p. 109) that "there are no data to suggest that contamination levels are higher in electromagnets than in other types of equipment."

[d] Assuming utility ownership is 85 percent of total (EPA, 1982).

[e] Based on reply comments to EPA's 22 April 1982 Proposed Rule.

[f] Assuming utility ownership is 100 percent of total (EPA, 1982).

[g] Assuming from EEI (1982, p. 9) that "twenty-two tests were available and all indicated PCB concentrations of less than 10 ppm."

N.A. = Not available.

Table S-2. Summary of Alternatives Analyzed

Equipment Category	Duration of Phase-Out Periods Assessed (Years)[a]	Frequency of Inspection Programs Assessed[b]	Assessment of Secondary Containment?	Assessment of Retrofilling?	Analysis of Credits for Efficiency Improvement?	Assessment of Relocation Opportunity?	Sensitivity Analysis?
PCB Capacitors:							
Nonsubstation Outdoor	0,5,6,7,10,15,20, ∞	None, Annually, Quarterly	N.A.	N.A.	Yes	No	Yes
Located in Substation or Restricted Areas	0,5,10,20,30, ∞	None, Quarterly	Yes	N.A.	Yes	No	Qualitative
Located Indoors or in Enclosed Areas	0,5,10,15,20, ∞	None, Quarterly	Qualitative	N.A.	Qualitative	No	Qualitative
Posing Exposure Risk to Food or Feed	0,2,3,5,6,10, ∞	None, Quarterly, Weekly	Qualitative	N.A.	Qualitative	Qualitative	Qualitative
Askarel Transformers:							
Utility-Owned	0,10,20,30, ∞	None, Quarterly	Yes	Yes	N.A.	No	Qualitative
Nonutility-Owned	0,10,20,30, ∞	None, Quarterly	Qualitative	Yes	N.A.	No	Qualitative
Posing an Exposure Risk to Food or Feed	0,2,3,5,6,7,10, ∞	None, Weekly	Qualitative	Yes	N.A.	Qualitative	Yes

Table S-2. Summary of Alternatives Analyzed (Continued)

Equipment Category	Duration of Phase-Out Periods Assessed (Years)[a]	Frequency of Inspection Programs Assessed[b]	Assessment of Secondary Containment?	Assessment of Retrofilling?	Analysis of Credits for Efficiency Improvement?	Assessment of Relocation Opportunity?	Sensitivity Analysis?
Mineral Oil Transformers							
Utility-Owned	0,10,20,30,∞	None, Annually	No	No	N.A.	No	Qualitative
Nonutility-Owned	Qualitative Assessment						
Electromagnets	Qualitative Assessment						
Voltage Regulators	Qualitative Assessment						
Cables	Qualitative Assessment						
Switches (including sectionalizers and motor starters)	Qualitative Assessment						
Circuit Breakers	Qualitative Assessment						
Reclosers	Qualitative Assessment						

[a] Zero indicates immediate phase-out (by the end of 1982); infinity indicates indefinite authorization (assumed to extend through 2030 for computational convenience).

[b] Individual inspection programs were assessed for most, but not all, phase-out periods, as indicated in Chapter 1.

N.A. = Not Applicable.

SOURCE: Putnam, Hayes & Bartlett, Inc.

otherwise have resulted from PCB spills. As a practical matter, the data required to estimate human exposure were not available,* so the incremental weight of PCBs spilled was used as a surrogate for injury to health and environment. The costs of these alternatives are the costs borne by society, either direct or indirect, that would not otherwise have been incurred.

By definition these benefits and costs are comparative -- they represent the incremental effects from the base case. Thus for each regulatory alternative the total costs and expected pounds of PCBs spilled were calculated over the life of the equipment or through the end of a phase-out period. Benefits were then calculated as the avoided PCB spills (in pounds) relative to the base case, and costs were calculated as the increase in costs borne by society, again relative to the base case. In addition, the cost-effectiveness of each alternative was assessed by calculating the ratio of costs to benefits. This ratio measures the incremental cost incurred on a "per spill-pound avoided" basis. Other things being equal,** the higher the ratio value the less attractive the alternative.

The principal results of these analyses are summarized in the following six paragraphs:

1. If the use of all PCB-containing electrical equipment is authorized indefinitely, approximately 2.2 million pounds of PCBs will be spilled, 99.95 percent of which will spill from PCB capacitors and askarel transformers.

---

* While some data were provided by EEI (1982, Volumes II and IV), information describing the physical distribution of PCB-containing electric equipment is sparse. This information is necessary to estimate the magnitude of direct exposure and of food and feed contamination that would result from PCB spills.

** However, other things are not always equal. A pound of PCBs spilled in a food or feed facility may result in greater exposure than a pound of PCBs spilled in an enclosed utility substation. Thus, judgment must be used in interpreting these cost-effectiveness ratios.

2. Of the four generic alternatives selected by EPA for study, accelerated replacement appears to dominate the other options, at least under average conditions. While accelerated replacement, retrofilling, and secondary containment are generally of similar cost-effectiveness for a given equipment category, retrofill is not feasible for capacitors, while containment may not reduce exposure as completely as replacement or retrofill. Inspection does not appear to be as effective as any of these measures in preventing spills (except for askarel transformers), although it may be useful in reducing the time required to detect and clean up spills.

3. The cost-effectiveness of accelerated replacement, however, varies dramatically among equipment categories. The cost-effectiveness ratios range from $230 per pound to $10,600,000 per pound, a range of over $10 million.

4. Within an equipment category, more accelerated replacement programs obviously result in fewer PCB spills, but also are nearly as cost-effective as the longer replacement programs.

5. While short replacement programs result in fewer PCB spills with cost-effectiveness nearly equivalent to longer programs, limitations in equipment manufacturing -- particularly capacitor manufacturing -- place a minimum boundary on the feasible length of replacement programs.

6. Further, while the total economic costs to society are increased as replacement programs are made shorter, the economic impact of the three mandated equipment replacement programs* on affected industries is very small.

---

* These three programs are nonsubstation outdoor PCB capacitors, PCB capacitors posing an exposure risk to food or feed, and PCB transformers posing an exposure risk to food or feed. Since the number of PCB electromagnets is extremely small (EPA, 1982), the impact of replacing PCB electromagnets posing an exposure risk to food or feed is negligible.

Each of these findings is discussed in more detail in the following sections.

PCB SPILLS FROM PCB-CONTAINING ELECTRICAL EQUIPMENT

The data collected by EEI/USWAG demonstrate that different types of PCB-containing electrical equipment leak with varying frequency. For transformers, the dominant spill mode is from moderate leaks which do not usually affect the operation of the transformer. Capacitor spills, on the other hand, result almost exclusively from a rupture of the capacitor can which is always accompanied by failure.* The data supplied by EEI/USWAG and by other respondents include spill rates for the various types of PCB-containing electrical equipment. These spill rates, which often vary by equipment type, location or use, can be used to estimate the PCB spills that will result from the continued use of this equipment if use is authorized indefinitely.

Table S-3 summarizes these figures. Of the total 2.2 million pounds estimated to be spilled, 99.95 percent is attributable to PCB capacitors and askarel transformers. The extremely low mineral oil equipment contribution to PCB spills stems directly from the fact that mineral oil equipment accounts for only 0.1 percent of the total PCBs contained in PCB-containing electrical equipment. This in turn results from the fact that the average PCB concentration in capacitors and askarel transformers is 10,000 to 50,000 times higher than the average concentration in mineral oil equipment.

Within the PCB capacitor category, nonsubstation outdoor capacitors account for the bulk of the estimated spill volume, due to their higher spill frequency. Askarel transformer spill frequencies are fairly similar across the three transformer categories, as reflected by the pounds spilled per piece of equipment figures. As nonutility askarel transformers outnumber either of the other two transformer categories, the majority of the spill volume is attributable to them.

---

* Not all failed capacitors rupture, however.

Table S-3. Estimated PCB Spills, by Equipment Category, for Indefinite Use Authorization

Equipment Category	Estimated Pounds Spilled	Pounds Spilled per Piece of Equipment	Percent of Total Pounds Spilled
PCB Capacitors			
Nonsubstation Outdoor	771,291	0.626	35.68
Substation or Restricted Area	43,315	0.028	2.00
Indoor or Enclosed Area	27,148	0.055	1.26
Posing an Exposure Risk to Food or Feed	128	0.027	0.01
Subtotal	841,882		38.95
Askarel Transformers			
Utility-Owned	315,264	7.95	14.59
Nonutility-Owned	994,338	10.86	46.01
Posing an Exposure Risk to Food or Feed	8,668	9.34	0.40
Subtotal	1,318,270		61.00
Mineral Oil Transformers	908	0.0004	0.04
Other Mineral Oil Equipment	260	N.C.	0.01
TOTAL	2,161,320		100.00

N.C. = Not Calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

COST-EFFECTIVENESS OF ALTERNATIVES WITHIN EQUIPMENT CATEGORIES

EPA selected four major alternatives for study: accelerated equipment replacement, equipment retrofill with non-PCB fluid, secondary containment, and more frequent inspection and maintenance of equipment. Retrofill and secondary containment, however, are not technically feasible for all equipment categories. For instance, PCB capacitors are hermetically sealed and thus cannot be retrofilled. Containment of pole-mounted equipment is not feasible either. In addition, secondary containment may not reduce exposure as completely as either replacement or retrofill.

For some equipment categories retrofill and/or containment are feasible. In these instances, they have approximately the same cost-effectiveness as accelerated replacement,* given the uncertainty in the underlying data. As shown in Table S-4, containment is estimated to be up to 29 percent cheaper than replacement, while retrofill is estimated to be up to 24 percent more expensive than replacement. While specific cost estimates were not available, the cost-effectiveness of containment for nonutility askarel transformers and askarel transformers posing an exposure risk to food or feed is believed to be approximately equal to that of utility askarel transformers.

Comments provided by EEI and by individual utilities indicate that inspection of capacitors would not reduce the number of spills nor shorten the spill detection time. For askarel transformers, the comments indicate that leaks progress from small to moderate, and that inspections can thus help to reduce the amount of PCBs spilled.

COST-EFFECTIVENESS OF ALTERNATIVES AMONG EQUIPMENT CATEGORIES

Given the broad range of PCB concentrations, spill rates, replacement costs and the like, it would not be

---

* These cost-effectiveness calculations are based on "average" costs. There may well be specific situations where retrofill or containment is less expensive than replacement.

Table S-4. Cost-Effectiveness of Retrofill and Secondary Containment Relative to 10-Year Phase-Out for Each Equipment Category

	Percent of 10-Year Phase-Out Cost-Effectiveness	
	Retrofill	Containment
PCB Capacitors		
Nonsubstation Outdoor PCB Capacitors	N.F.	N.F.
PCB Capacitors in Substation or Restricted Areas	N.F.	71
PCB Capacitors Located Indoors or in Enclosed Areas	N.F.	N.C.
PCB Capacitors Posing Exposure Risk to Food or Feed	N.F.	N.C.
Askarel Transformers		
Utility-Owned Askarel Transformers	124	88
Nonutility-Owned Askarel Transformers	119	N.C.*
Askarel Transformers Posing Exposure Risk to Food or Feed	119	N.C.*
Mineral Oil Transformers	N.C.	N.C.

N.F. = Not feasible.

N.C. = Not calculated.

N.C.* = Not calculated but believed to be similar to utility-owned askarel transformers.

SOURCE: Putnam, Hayes & Bartlett, Inc.

surprising to find a broad range of cost-effectiveness among the equipment categories. Table S-5 summarizes this range using a 10-year accelerated phase-out as the basis for comparison. The cost-effectiveness ratios vary by a factor of 50,000, from $230 per pound for nonsubstation outdoor capacitors to $10.6 million per pound for mineral oil transformers.

The range in cost-effectiveness among the capacitor categories results mainly from differing spill rates. The available data suggest that nonsubstation outdoor capacitors have substantially higher spill rates than the other three capacitor categories and hence the lowest cost-effectiveness. The three askarel transformer categories are fairly tightly clustered, reflecting similar spill rate and cost characteristics. While accelerated replacement of askarel transformers is not as cost-effective as nonsubstation outdoor capacitors, it is more cost-effective than the other capacitor subcategories.

Accelerated replacement of mineral oil transformers is much less cost-effective than any of the other equipment types for two reasons. First, those transformers contaminated with PCBs in excess of 50 parts per million, approximately one in ten, must be identified through testing of each of the over 22 million mineral oil transformers. This testing is quite expensive. Second, the PCB concentration level in these transformers is extremely low, averaging between 50 and 500 parts per million as compared to 700,000 to 1 million parts per million for askarel transformers and PCB capacitors. Thus the amount of PCBs spilled per gallon of fluid spilled is very small.

COST-EFFECTIVENESS OF ALTERNATIVE PHASE-OUT PERIODS

The direct costs incurred as a result of accelerated replacement clearly increase as the phase-out period is shortened. Under shorter phase-outs, equipment with a larger percentage of remaining useful life, and hence a higher economic value, is removed from service. This lost economic value is a large component of the total cost. In addition, disposal costs are incurred earlier than would otherwise have been the case. The present value of the difference in timing also adds to the cost.

Table S-5. Cost-Effectiveness of 10-Year Accelerated Phase-Out Across Equipment Categories[a]

	Cost-Effectiveness ($/lb.)	Ranking
PCB Capacitors		
Nonsubstation Outdoor PCB Capacitors	230	1
PCB Capacitors in Substation or Restricted Areas	11,860	6
PCB Capacitors Located Indoors or in Enclosed Areas	7,950	5
PCB Capacitors Posing Exposure Risk to Food or Feed	13,603	7
Askarel Transformers		
Utility-Owned Askarel Transformers	1,880	4
Nonutility-Owned Askarel Transformers	1,490	2
Askarel Transformers Posing Exposure Risk to Food or Feed	1,760	3
Mineral Oil Transformers	10,600,000	8

[a] The exposure risk resulting from a pound of PCBs spilled may vary across equipment categories. Thus, judgment must be used in interpreting these cost-effectiveness ratios and rankings.

SOURCE: Putnam, Hayes & Bartlett, Inc.

However, as shown in Table S-6, the cost-effectiveness of a phase-out is not strongly dependent on its duration. While shorter phase-outs appear to be less cost-effective than longer phase-out periods, a 30 percent or even 50 percent cost-effectiveness differential is dwarfed by the uncertainty in the underlying data (spill rates, replacement cost, etc.).

In a world of perfect certainty it would be theoretically possible to choose the precise phase-out period which maximizes net social benefits. However, the data available, both with respect to costs and benefits, are not sufficiently precise to support the selection of a longer, rather than shorter phase-out. Rather they are sufficient only to provide an order-of-magnitude estimate of cost-effectiveness. If phase-out for a given equipment category is judged to be desirable, criteria other than economic considerations will determine the phase-out period (for example, minimizing expected PCB releases subject to equipment manufacturing capacity constraints).

CONSTRAINTS WHICH AFFECT THE SELECTION OF PHASE-OUT DURATION

While the data concerning the costs and benefits of avoiding PCB spills are not sufficiently precise to differentiate among phase-out periods for a given equipment classification, there are two different types of technical constraints which determine the shortest feasible phase-out period for the three types of equipment* for which accelerated replacement is required. These constraints are the available PCB disposal capacity and the available replacement capacitor manufacturing capacity.

---

* The three types of equipment are nonsubstation PCB capacitors, PCB capacitors posing an exposure risk to food or feed, and PCB transformers posing an exposure risk to food or feed. The number of askarel electromagnets posing an exposure risk to food or feed is assumed to be very small by EPA.

Table S-6. Cost-Effectiveness of Other Phase-Out Periods as a Percentage of the 10-Year Phase-Out Cost-Effectiveness

	Phase-Out Period		
	Immediate %	20 Years %	30 Years %
PCB Capacitors			
Nonsubstation Outdoor PCB Capacitors	111	80	N.C.
PCB Capacitors in Substation or Restricted Areas	111	80	63
PCB Capacitors Located Indoors or in Enclosed Areas	112	80	N.C.
PCB Capacitors Posing Exposure Risk to Food or Feed	112	N.C.	N.C.
Askarel Transformers			
Utility-Owned Askarel Transformers	111	81	62
Nonutility-Owned Askarel Transformers	111	81	62
Askarel Transformers Posing Exposure Risk to Food or Feed	111	N.C.	N.C.
Mineral Oil Transformers	85	193	952

N.C. = Not calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Both PCB capacitors and the fluid and rinse from askarel transformers must be incinerated. The maximum annual disposal requirement (including that associated with failure or retirement of other PCB-containing electrical equipment) is 16.8 million pounds of PCBs, while the available capacity is 35 million pounds per year. Disposal capacity is sufficient to accommodate the required equipment phase-outs.

The total demand for capacitors includes those capacitors required due to the phase-out as well as those that will be purchased for new installations, etc., independent of the phase-out. The maximum annual demand associated with the phase-out is estimated to be 29.1 million KVAR, while the nonphase-out related demand is estimated at 9.7 to 20.3 million KVAR per year. Thus, the maximum annual capacitor demand is estimated to be 38.8 to 49.4 million KVAR. Based on responses to the National Electric Manufacturers Association survey (1982), and on conversations with capacitor manufacturers, the maximum available capacity is estimated at 47.85 million KVAR per year.* Based on these estimates, it appears that the required phase-outs are feasible, although a small amount of nonphase-out related purchases may be deferred for several years. However, shorter capacitor phase-outs would probably result in substantial deferral of nonphase-out related purchases.

ECONOMIC IMPACT ON AFFECTED INDUSTRIES

The costs associated with the required phase-outs will be borne by the electric utility industry, the food and feed industry, and their customers. However, the distributional impacts associated with these phase-outs are not large.

The net present value of the nonsubstation capacitor phase-out costs is only 0.05 percent of 1979 net electric plant in service nationally, and the maximum annual increase in required investment as a consequence of the phase-out is only 0.34 percent of the 1978 to 1979 growth in net electric plant investment. From the customers' perspective, the maximum annual increase in required revenues is only 0.1 percent of 1979 national electric operating revenues.

---

* Unless capacitor price were to rise substantially.

For askarel transformers and PCB capacitors posing an exposure risk to food or feed, the before-tax net present value of phase-out costs is less than 0.1 percent of 1976 assets in the food and feed industry. The total increase in cash flow requirements (before-tax) in 1983 and 1984 attributable to the phase-out is less than 0.2 percent of the estimated 1979 internal cash flow of the food and feed industry.

Some of these food and feed transformers and capacitors may be owned by the utility industry. Even if all of these transformers and capacitors are owned by the electric utility industry, the total impact on the utility industry would be very small, less than 10 percent of the impacts estimated for the phase-out of nonsubstation outdoor PCB capacitors alone.

INTRODUCTION

CHAPTER 1

Section 6(e) of the Toxic Substances Control Act (TSCA) prohibits all manufacture, processing, distribution in commerce, and use of PCBs after 1 July 1979. However, the statute does provide for the continued use of PCBs in a "totally enclosed manner." A totally enclosed manner is defined to be "any manner which will ensure that any exposure of human beings or the environment to a polychlorinated biphenyl will be insignificant as determined by the Administrator by rule." In addition, TSCA also allows EPA to authorize by rule the continued use of PCBs in a manner other than in a "totally enclosed manner" if EPA finds such use "will not present an unreasonable risk of injury to health or the environment."

In the 31 May 1979 regulations promulgated to implement section 6(e) of TSCA, EPA designated all intact, nonleaking electrical capacitors, electromagnets, and transformers as "totally enclosed," thus permitting their continued use without regulation. However, the Environmental Defense Fund petitioned the U.S. Court of Appeals to review three aspects of the rule, including the designation of nonleaking electrical equipment as a totally enclosed use. In a 30 October 1980 decision, the court found that there was no substantial evidence in the record to support the Agency's classification of transformers, capacitors, and electromagnets as totally enclosed. The court remanded this and another portion* of the regulation to EPA for further action.

---

* The second remand dealt with EPA's determination that with one exception PCBs in concentrations lower than 50 ppm were not subject to regulation.

The effect of the court's decision was to make the continued use of transformers, capacitors, and electromagnets containing PCBs at any concentration a violation of section 6(e) of TSCA. To avoid the disruption of electrical service that would otherwise have resulted, EPA, EDF, and several intervenors requested an 18-month stay of the order, during which time additional data were to be collected, a new rulemaking undertaken, and certain interim risk reduction measures implemented. On 12 February 1981 the court granted a stay of its earlier order until 12 August 1982, subject to the above conditions. The current rulemaking is in response to the 12 February 1981 stay, and is subject to the court-ordered schedule.

The court's order requires EPA to promulgate a final rule within six months of receipt of the additional data to be provided by the Edison Electric Institute (EEI, 1982) through the Utility Solid Waste Activities Group (USWAG). Since the final EEI/USWAG study was received on 19 February 1982, the final rule for the use of PCBs in electrical equipment must be delivered to the Federal Register by 19 August 1982.

EPA is authorizing eight uses of PCB electrical equipment pursuant to section 6(e)(2)(B) of TSCA. Specifically EPA is authorizing the use of PCBs in:

- Capacitors
    - -- PCB capacitors posing an exposure risk to food or feed: through 1988;
    - -- PCB capacitors within restricted access electrical substations or in contained and restricted access indoor locations: indefinitely;
    - -- All other PCB capacitors: through 1988;
- Transformers*
    - -- PCB transformers posing an exposure risk to food or feed: through 1985 subject to weekly inspection and maintenance;

---

* Excluding railroad transformers.

  - All other PCB transformers: indefinitely subject to quarterly inspection and maintenance;
  - All PCB-contaminated transformers: indefinitely;

- Electromagnets
  - PCB electromagnets posing an exposure risk to food or feed: through 1985 subject to weekly inspection and maintenance;*
  - All other electromagnets: indefinitely;
- Voltage regulators: indefinitely;
- Cables: indefinitely;
- Switches (including sectionalizers and motor starters): indefinitely;
- Circuit breakers: indefinitely; and
- Reclosers: indefinitely.

While EPA does not believe that this rule is a major rule as defined in section 1.b. of Executive Order 12291, this Regulatory Impact Analysis (RIA) has nonetheless been prepared addressing, to the extent possible, the requirements set out in E.O. 12291. However, due to the constraints imposed by available data and by the court-ordered schedule, there are several limitations to the analysis which should be well-understood. Accordingly, each of these limitations is discussed below.

First, the cost/benefit and cost-effectiveness analyses are themselves limited by available data and time. The health impacts of PCB spills or releases cannot be quantified at this time, as some of the data necessary to estimate human exposure are unavailable.* While a methodology for estimating human exposure could be developed given additional time, for the purposes of this analysis, the expected weight of PCBs spilled is used as a surrogate for health impacts.

---

* While no estimate of the population of this equipment exists, EPA believes the number to be extremely small.

Second, all estimates of number of units in service, equipment, volume, spill rates, costs of replacement, retrofill, containment, and the like are based on the data provided by EEI (1982), and by other parties who submitted written or oral comments. While these data are believed to be the best available, they have not been independently verified except through comparisons for consistency. Thus, errors or bias may exist.

Finally, data concerning the nonutility use of PCB electrical equipment are generally less comprehensive than those for utility-owned equipment. While some information as to the amounts of PCB equipment, the PCB concentrations, and the spill rates is available, these data are neither complete nor consistently collected. Thus the amount of nonutility PCB equipment in service, and the distribution of this equipment within the commercial and industrial sectors, are less certain than the distribution of utility-owned equipment. Hence, while sufficient data are available to support an assessment of nonutility equipment, the results of such analysis are less certain than those for utility-owned equipment.

Despite these schedule- and data-related constraints, a methodology for evaluating alternative regulations has been developed and consistently applied. The results can be used to assess cost-effectiveness as well as the potential risk of injury to health or the environment for each regulatory alternative and equipment classification.

---

* While some data were provided by EEI (1982, Volumes II and IV), information describing the physical distribution of PCB-containing electric equipment is sparse. This information is necessary to estimate the magnitude of direct exposure and of food and feed contamination that would result from PCB spills or leaks.

For purposes of this regulatory impact analysis, the base case, against which all alternatives will be compared, is the case where the use of all PCB-containing electrical equipment is authorized indefinitely. Because PCB concentration, equipment costs, spill rates, and exposure vary by equipment type and use, alternatives to the base case must be formulated and analyzed for each type of equipment. Thus, the remainder of this section is dedicated to a discussion of the alternatives considered for each equipment type. For purposes of this analysis, the eight authorized equipment types were reclassified into five equipment categories:

- PCB capacitors
    - -- Nonsubstation outdoor PCB capacitors;*
    - -- PCB capacitors located in substations or in restricted areas;
    - -- PCB capacitors located indoors or in enclosed areas;
    - -- PCB capacitors posing an exposure risk to food or feed;

---

* Assumed to include PCB capacitors other than those: 1) posing an exposure risk to food or feed; or 2) located within restricted access electrical substations or in contained and restricted access indoor locations.

- Askarel transformers*
  - Utility-owned askarel transformers;
  - Nonutility-owned askarel transformers;
  - Askarel transformers posing an exposure risk to food or feed;
- Mineral oil transformers;
- Mineral oil electromagnets, mineral oil voltage regulators, oil-filled cables, and mineral oil switches (including sectionalizers and motor starters); and
- Mineral oil circuit breakers and mineral oil reclosers.

As Table 1 shows, the first two categories, PCB capacitors and askarel transformers, account for 99.91 percent of the total PCBs contained in electrical equipment.** The third category, mineral oil transformers, accounts for essentially all of the remaining 0.09 percent of the PCBs. The six other equipment types were split into two groups, roughly according to their average level of PCB contamination.

Alternatives to the base case include equipment phase-outs varying in length from 0 to 30 years, retrofilling (where technically feasible), secondary containment (where technically feasible), and inspection and maintenance programs to reduce spill volume and/or exposure. The alternatives analyzed for each of the equipment classifications are summarized in Table 2.

---

* Nonrailroad transformers only.

** These estimates do not account for PCBs in small capacitors used for high-intensity applications, fluorescent lighting ballast, or in small appliances. These capacitors were estimated to contain 180 million pounds of PCBs in 1979 (Versar, 1977, pp. 1-5, 1-6). It is unclear how many of these capacitors still remain in service; moreover, EPA has not identified any cost-effective means of regulating their use.

Table 1. PCB-Containing Electrical Equipment

Equipment Type	Number of Units	Total Fluid Volume (Gallons)	Total Pounds PCBs	Average PCB Concentration
PCB Capacitors				
Nonsubstation outdoor	1,232,000	3,326,000	38,595,000	100%
Located in substations or restricted areas	1,568,000	4,234,000	49,121,000	100%
Located indoors or in enclosed areas	490,000	979,000	11,360,000	100%
Posing exposure risk to food or feed	4,500	9,000	106,000	100%
	3,294,000	8,548,000	99,182,000	
Askarel Transformers				
Utility-owned	39,600	8,525,000	74,597,000	70%
Nonutility-owned	91,600	22,899,000	200,370,000	70%
Posing an exposure risk to food or feed	900	232,000	2,030,000	70%
	132,100	31,656,000	276,997,000	
Mineral Oil[a] Transformers	25,284,000	1,197,957,500	328,000	36 ppm
Electromagnets[b]	7,700	770,000	300[c]	50 ppm[c]
Voltage Regulators[d]	170,600	20,989,000	8,200	49 ppm

Table 1. PCB-Containing Electrical Equipment (Continued)

Equipment Type	Number of Units	Total Fluid Volume (Gallons)	Total Pounds PCBs	Average PCB Concentration
Motor Starters	N.A.	N.A.	N.A.	10 ppm[e]
Switches/ Sectionalizers[f]	386,000	1,416,000	300	31 ppm
Cable[d]	7,700 miles	35,800,000	2,700[g]	10 ppm[g]
Circuit Breakers[d]	213,000	161,570,000	15,000	12 ppm
Reclosers[d]	200,000	4,005,000	500	16 ppm
	29,687,900+ 7,700 miles	1,462,711,500	376,534,000	

SOURCE: EEI/USWAG study (1982, pp. 9, 10, 109, A-14, A-15). Average concentration calculated by Putnam, Hayes & Bartlett, Inc. from EEI data, except where cited.

[a] Assuming utility ownership is 80 percent of total (EPA, 1982).

[b] Assuming utility ownership is 1 percent of total (EPA, 1982).

[c] Assuming from EEI (1982, p. 109) that "there are no data to suggest that contamination levels are higher in electromagnets than in other types of equipment."

[d] Assuming utility ownership is 85 percent of total (EPA, 1982).

[e] Based on reply comments to EPA's 22 April 1982 Proposed Rule.

[f] Assuming utility ownership is 100 percent of total (EPA, 1982).

[g] Assuming from EEI (1982, p. 9) that "twenty-two tests were available and all indicated PCB concentrations of less than 10 ppm."

N.A. = Not available.

Table 2. Summary of Alternatives Analyzed

Equipment Category	Duration of Phase-Out Periods Assessed (Years)[a]	Frequency of Inspection Programs Assessed[b]	Assessment of Secondary Containment?	Assessment of Retrofilling?	Analysis of Credits for Efficiency Improvement?	Assessment of Relocation Opportunity?	Sensitivity Analysis?
PCB Capacitors:							
Nonsubstation Outdoor	0,5,6,7,10,15,20,∞	None, Annually, Quarterly	N.A.	N.A.	Yes	No	Yes
Located in Substation or Restricted Areas	0,5,10,20,30,∞	None, Quarterly	Yes	N.A.	Yes	No	Qualitative
Located Indoors or in Enclosed Areas	0,5,10,15,20,∞	None, Quarterly	Qualitative	N.A.	Qualitative	No	Qualitative
Posing Exposure Risk to Food or Feed	0,2,3,5,6,10,∞	None, Quarterly, Weekly	Qualitative	N.A.	Qualitative	Qualitative	Qualitative
Askarel Transformers:							
Utility-Owned	0,10,20,30,∞	None, Quarterly	Yes	Yes	N.A.	No	Qualitative
Nonutility-Owned	0,10,20,30,∞	None, Quarterly	Qualitative	Yes	N.A.	No	Qualitative
Posing an Exposure Risk to Food or Feed	0,2,3,5,6,7,10,∞	None, Weekly	Qualitative	Yes	N.A.	Qualitative	Yes

Table [illegible] Summary of Alternatives Analyzed (continued)

Equipment Category	Duration of Phase-Out Periods Assessed (Years)[a]	Frequency of Inspection Programs Assessed[b]	Assessment of Secondary Containment?	Assessment of Retrofilling?	Analysis of Credits for Efficiency Improvement?	Assessment of Relocation Opportunity?	Sensitivity Analysis?
Mineral Oil Transformers							
Utility-Owned	0,10,20,30,∞	None, Annually	No	No	N.A.	No	Qualitative
Nonutility-Owned	Qualitative Assessment						
Electromagnets	Qualitative Assessment						
Voltage Regulators	Qualitative Assessment						
Cables	Qualitative Assessment						
Switches (including sectionalizers and motor starters)	Qualitative Assessment						
Circuit Breakers	Qualitative Assessment						
Reclosers	Qualitative Assessment						

[a] Zero indicates immediate phase-out (by the end of [illegible]); infinity indicates indefinite authorization (assumed to extend through 2030 for computational convenience).

[b] Individual inspection programs were assessed for most, but not all, phase-out periods, as indicated in Chapter 1.

N.A. = Not Applicable.

SOURCE: Putnam, Hayes & Bartlett, Inc.

PCB CAPACITORS

Large power capacitors are used for precise control of voltage level and for power factor correction in order to reduce the power consumption of inductive loads (e.g., electric motors). As a result, they are widely used by both utilities and large commercial and industrial power users. Virtually all capacitors manufactured prior to 1978 were filled with PCBs. Utility ownership of PCB capacitors is estimated by EEI (1982, pp. 9, 10) at 2.8 million units, containing over 87 million pounds of PCBs. EPA estimates that utility PCB capacitors account for 85 percent of the total in service. Adjusting for the smaller fluid volume of these nonutility units, this implies that a total of 99 million pounds of PCBs are contained in PCB capacitors.

Nonsubstation Outdoor PCB Capacitors

The regulatory alternatives considered for nonsubstation outdoor PCB capacitors include the following.

- Indefinite authorization (Base Case) -- indefinite authorization of the use of existing equipment for the remainder of its useful life.

- Twenty-year phase-out -- replacement of all capacitors by 2002, starting accelerated replacement in 1993.

- Fifteen-year phase-out -- replacement of all capacitors by 1997, starting accelerated replacement in 1988.

- Ten-year phase-out -- replacement of all capacitors by 1992, starting accelerated replacement in 1983.

- Seven-year phase-out -- replacement of all capacitors by 1989, starting accelerated replacement in 1983.

- Six-year phase-out -- replacement of all capacitors by 1988, starting accelerated replacement in 1984 (allowing a one-year period for phase-out planning).

- Five-year phase-out -- replacement of all capacitors by 1987, starting accelerated replacement in 1983.

- Immediate phase-out -- replacement of all capacitors in 1982. While this alternative is probably not feasible, estimates of costs and benefits are provided as if this alternative could be implemented.

- Inspection and maintenance -- annual or quarterly inspections* of each capacitor to facilitate the detection and clean-up of PCB spills. These alternatives are evaluated in conjunction with indefinite authorization, 15-year, 10-year, 5-year, and immediate equipment phase-outs.

PCB Capacitors Located in Substations or Restricted Areas

The regulatory alternatives considered for PCB capacitors located in substations or restricted areas include the following.

- Indefinite authorization (Base Case) -- indefinite authorization of the use of existing equipment for the remainder of its useful life.

- Thirty-year phase-out -- replacement of all capacitors by 2012, starting accelerated replacement in 1993.

- Twenty-year phase-out -- replacement of all capacitors by 2002, starting accelerated replacement in 1993.

- Ten-year phase-out -- replacement of all capacitors by 1992, starting accelerated replacement in 1983.

---

* While EEI data (1982, p. 82) indicate that utilities inspect their equipment with varying frequency, for purposes of this analysis the current level of inspection activity was assumed to be zero. This is a conservative assumption as it results in a slight overestimation of costs.

- Five-year phase-out -- replacement of all capacitors by 1987, starting accelerated replacement in 1983.

- Immediate phase-out -- replacement of all capacitors in 1982. While this alternative is probably not feasible, estimates of costs and benefits are provided as if this alternative could be implemented.

- Immediate secondary containment of potential spills -- construction of a dike and, where necessary, a concrete pad under each capacitor bank in 1982, followed by mandatory biweekly inspection of each dike over the remaining equipment life.

- Inspection and maintenance -- quarterly inspection of each capacitor to facilitate the detection and clean-up of PCB spills. This alternative is evaluated in conjunction with indefinite authorization, 30-year, 20-year, 10-year, 5-year, and immediate equipment phase-outs.

PCB Capacitors Located Indoors or in Enclosed Areas

The regulatory alternatives considered for PCB capacitors located indoors or in enclosed areas include the following.

- Indefinite authorization (Base Case) -- indefinite authorization of the use of existing equipment for the remainder of its useful life.

- Twenty-year phase-out -- replacement of all capacitors by 2002, starting accelerated replacement in 1993.

- Fifteen-year phase-out -- replacement of all capacitors by 1997, starting accelerated replacement in 1988.

- Ten-year phase-out -- replacement of all capacitors by 1992, starting accelerated replacement in 1983.
- Five-year phase-out -- replacement of all capacitors by 1987, starting accelerated replacement in 1983.
- Immediate phase-out -- replacement of all capacitors in 1982. While this alternative is probably not feasible, estimates of costs and benefits are provided as if this alternative could be implemented.
- Inspection and maintenance -- quarterly inspection of each capacitor to facilitate the detection and clean-up of PCB spills. This alternative is evaluated in conjunction with all of the above options.

PCB Capacitors Posing an Exposure Risk to Food or Feed

The regulatory alternatives considered for PCB capacitors posing an exposure risk to food or feed include the following.

- Indefinite authorization (Base Case) -- indefinite authorization of the use of existing equipment for the remainder of its useful life.
- Ten-year phase-out -- replacement of all capacitors by 1992, starting accelerated replacement in 1983.
- Six-year phase-out -- replacement of all capacitors by 1988, starting accelerated replacement in 1984 (allowing a one-year period for phase-out planning).
- Five-year phase-out -- replacement of all capacitors by 1987, starting accelerated replacement in 1983.

- Three-year phase-out -- replacement of all capacitors by 1985, starting accelerated replacement in 1983.

- Two-year phase-out -- replacement of all capacitors by 1984, starting accelerated replacement in 1983.

- Immediate phase-out -- replacement of all capacitors in 1982. While this alternative is probably not feasible, estimates of costs and benefits are provided as if this alternative could be implemented.

- Inspection and maintenance -- quarterly or weekly inspection of each capacitor to facilitate the detection and clean-up of PCB spills. Weekly inspections were evaluated in conjunction with all of the above alternatives while quarterly inspections were evaluated in conjunction with all except the 10-year, 6-year, and 3-year equipment phase-outs.

ASKAREL TRANSFORMERS

Transformers are used to raise or lower electric voltage. As a result, they are in widespread use, owned either by electric utilities or by commercial or industrial concerns which use significant amounts of electricity. Most transformers currently in use are mineral oil transformers, so named because mineral oil is the dielectric fluid. However, a number of transformers are askarel transformers, the dielectric fluid of which is about 70 percent PCBs by volume. Askarel transformers are considerably more expensive than mineral oil transformers of equivalent size, but the superior fire protection properties of the PCB dielectric fluid permit their use in areas where mineral oil transformers would require substantial (and expensive) additional fire protection measures.

Recent EEI estimates (1982, pp. 60, 64) obtained by sampling many of the larger electric utilities indicate that approximately 40,000 utility-owned askarel transformers are currently in service, containing over 74 million pounds of PCBs. Versar (1978, p. 19) estimates that utility-owned askarel transformers comprise only 30 percent of the total number of askarel transformers currently in service. This would imply that a total of 131,000 askarel transformers are now in service, containing nearly 300 million pounds of PCBs.*

Utility-Owned Askarel Transformers

The regulatory alternatives considered for utility-owned askarel transformers include the following.

- Indefinite authorization (Base Case) -- indefinite authorization of the use of existing equipment for the remainder of its useful life.
- Thirty-year phase-out -- replacement of all transformers by 2012, starting accelerated replacement in 2003.
- Twenty-year phase-out -- replacement of all transformers by 2002, starting accelerated replacement in 1993.
- Ten-year phase-out -- replacement of all transformers by 1992, starting accelerated replacement in 1983.
- Immediate phase-out -- replacement of all transformers in 1982. While this alternative is probably not feasible, estimates of costs and benefits are provided as if this alternative could be implemented.
- Immediate retrofill of transformers -- draining of fluid, one rinse, and subsequent use of equipment to remove PCBs for all transformers to reduce PCB concentrations.

---

* Industry data indicate that nonutility askarel transformers are, on average, larger than utility-owned units. If nonutility units were the same size as utility units, the total amount of PCBs contained in askarel transformers would be 250 million pounds.

- Immediate secondary containment of potential spills -- construction of a dike and, where necessary, a concrete pad for all transformers in 1982, with subsequent biweekly inspection of every dike over the remaining equipment life.

- Inspection and maintenance -- quarterly inspection of each transformer to facilitate the detection and clean-up of PCB spills. This alternative is evaluated in conjunction with indefinite authorization, 30-year, 20-year, 10-year, and immediate equipment phase-outs.

Nonutility-Owned Askarel Transformers

The regulatory alternatives considered for askarel transformers include the following.

- Indefinite authorization (Base Case) -- indefinite authorization of the use of existing equipment for the remainder of its useful life.

- Thirty-year phase-out -- replacement of all transformers in 2012, starting accelerated replacement in 2003.

- Twenty-year phase-out -- replacement of all transformers by 2002, starting accelerated replacement in 1993.

- Ten-year phase-out -- replacement of all transformers by 1992, starting accelerated replacement in 1983.

- Immediate phase-out -- replacement of all transformers in 1982. While this alternative is probably not feasible, estimates of costs and benefits are provided as if this alternative could be implemented.

- Immediate retrofill of transformers -- draining of fluid, one rinse, and the subsequent use of equipment to remove PCBs for all transformers to reduce PCB concentrations.

- Inspection and maintenance -- quarterly inspection of each transformer to facilitate the detection and clean-up of PCB spills. This alternative is evaluated in conjunction with indefinite authorization, 30-year, 20-year, 10-year, and immediate equipment phase-out.

Askarel Transformers Posing an Exposure Risk to Food or Feed

The regulatory alternatives considered for askarel transformers posing an exposure risk to food or feed include the following.

- Indefinite authorization (Base Case) -- indefinite authorization of all existing equipment for the remainder of its useful life.
- Ten-year phase-out -- replacement of all transformers by 1992, starting accelerated replacement in 1983.
- Seven-year phase-out -- replacement of all transformers by 1989, starting accelerated replacement in 1983.
- Six-year phase-out -- replacement of all transformers by 1988, starting accelerated replacement in 1983.
- Five-year phase-out -- replacement of all transformers by 1987, starting accelerated replacement in 1983.
- Three-year phase-out -- replacement of all transformers by 1985, starting accelerated replacement in 1984 (allowing a one-year period for phase-out planning).
- Two-year phase-out -- replacement of all transformers by 1984, starting accelerated replacement in 1983.
- Immediate retrofill of transformers -- draining of fluid, one rinse, and the subsequent use of equipment to remove PCBs for all transformers to reduce PCB concentrations.

- Inspection and maintenance -- weekly inspection of each transformer to facilitate the detection and clean-up of PCB spills. This alternative is evaluated in conjunction with all of the above options except retrofill.

MINERAL OIL TRANSFORMERS

As discussed above, most transformers now in use are mineral oil transformers; EEI (1982, p. 61) estimates that current electric utility ownership exceeds 20 million units. Prior to public awareness of the health and environmental effects of PCBs, mineral oil and askarel transformers were often serviced with the same equipment, and in some cases askarel dielectric fluid was mixed with mineral oil. As a result, EEI (1982, p. 67) estimates that almost 60 percent of the mineral oil transformers in service contain PCBs at some detectable level (in excess of 1 ppm). However, only 11.8 percent of the mineral oil transformers contain PCBs in excess of 50 ppm, and only 1.1 percent contain PCBs in concentrations exceeding 500 ppm. The total amount of PCBs estimated by EEI (1982, p. 69) to be contained in utility mineral oil transformers is 262,000 pounds.

The annual spill rate of utility mineral oil transformers is estimated by EEI (1982, pp. 72, 74) to be 0.008 spills per transformer per year, with an average PCB release of 0.005 pounds per spill. The number of nonutility-owned mineral oil transformers is unknown.

The regulatory alternatives considered for utility-owned mineral oil transformers include the following.

- Indefinite authorization (Base Case) -- authorization of the use of all mineral oil transformers for their remaining useful life. Common container collection and testing is permitted for PCB-contaminated mineral oil.

- Thirty-year phase-out -- individual identification and replacement of all mineral oil transformers containing PCBs in excess of 50 ppm, starting accelerated replacement in 2003 and finishing in 2012.

- Twenty-year phase-out -- individual identification and replacement of all mineral oil transformers containing PCBs in excess of 50 ppm, starting accelerated replacement in 1993 and finishing in 2002.

- Ten-year phase-out -- individual identification and replacement of all mineral oil transformers containing PCBs in excess of 50 ppm, starting accelerated replacement in 1983 and finishing in 2012.

- Immediate phase-out -- identification and replacement in 1982 of all mineral oil transformers containing PCBs in excess of 50 ppm. While this alternative may not be feasible, estimates of costs and benefits are provided as if this alternative could be implemented.

- Inspection and maintenance -- one inspection per year of all mineral oil transformers to facilitate the detection and clean-up of PCB spills. This alternative is evaluated in conjunction with an indefinite authorization of PCB-contaminated transformers ($>$50 ppm PCB). Common container collection and testing of contaminated mineral oil is permitted. Due to the large costs associated with individually testing every mineral oil transformer, this alternative is less expensive than testing all units initially, but only inspecting those units with PCB concentrations greater than 50 ppm.

ELECTROMAGNETS, VOLTAGE REGULATORS, AND SWITCHES (INCLUDING SECTIONALIZERS AND MOTOR STARTERS)

These types of electrical equipment, all of which utilize mineral oil, have been identified as being contaminated with PCBs. Electromagnets, while owned by utilities, have no direct role in the production or distribution of electricity. Their principal use is in coal mining or in coal handling activities. Voltage regulators, switches, and sectionalizers are used in utility transmission and distribution systems. Motor starters are used in industries requiring large electric motors.

These types of equipment have been grouped together for two reasons. First, they are much less extensively used than mineral oil transformers, and are estimated by EEI to contain many fewer pounds of PCBs.* While fewer in number, the average PCB contamination of these types of equipment is estimated by EEI or by respondents to EPA to be similar to that of mineral oil transformers -- 30 to 50 ppm. Second, fewer data are available as to the number of equipment items and the associated PCB concentrations, spill rates, and phase-out/retrofill costs.

Given this shortage of data, regulatory alternatives have been assessed in a qualitative manner.

CIRCUIT BREAKERS, CABLES, AND RECLOSERS

Circuit breakers, cables, and reclosers are three other types of mineral oil equipment used in utility transmission and distribution systems. They too are few in number relative to mineral oil transformers, and are estimated by EEI (1982, p. 10) to contain approximately 15,300 pounds of PCBs. They are distinguished from the previous equipment group by a lower average level of PCB contamination. EEI (1982, pp. 93, 100) estimates that the average contamination of circuit breakers, cables, and reclosers is in the range of 10 to 15 ppm, approximately one third the level of mineral oil transformers.

Given the shortage of data and the low levels of PCB contamination, the consideration of regulatory alternatives was both qualitative and limited.

---

* One possible exception is motor starters, for which no estimate of the number of units in use is available.

ASSESSING COSTS CHAPTER 3

As described above, the cost to society of the PCB Use Rule is measured incrementally relative to a base case in which the use of all PCB-containing electrical equipment is authorized indefinitely without restriction.* As defined, the present value of these costs measures the monetary burden or penalty society bears in order to avoid PCB exposure. These social costs include the incremental out-of-pocket costs to owners or users of PCB-containing electrical equipment (for inspection, accelerated purchase of new equipment, and accelerated disposal of PCBs), indirect costs that may change as a result of the rule (like avoiding the cost of a business closing as a result of a PCB spill), and transitional costs like those that would result from power disruption during a wide-scale immediate phase-out of all PCB-containing electrical equipment.* As a practical matter, the following analysis focuses on identifiable direct out-of-pocket costs. In cases where indirect or transitional costs may be significant, they are discussed.

---

* In the absence of this rulemaking, the Appeals Court mandate would issue directly, resulting in an immediate ban on the use of PCB-containing electrical equipment. Thus, while a hypothetical immediate phase-out of all PCB-containing electrical equipment could properly be considered the "base case," the more conventional measurement of cost relative to a "no regulation" case was considered a more useful assessment of economic impacts.

In order to estimate the social cost to avoid PCB exposure for different regulatory alternatives, a quantitative methodology was developed and applied to the five categories of PCB-containing electrical equipment: PCB capacitors; askarel transformers; mineral oil transformers; circuit breakers, reclosers, and oil-filled cables; and other equipment types (switches, voltage regulators, and electromagnets). While data limitations precluded a quantitative analysis of the last two equipment groups, they account for less than 0.3 percent of the PCBs used in electrical equipment. Furthermore, comprehensive estimates of the population and average characteristics of nonutility mineral oil transformers were not available. However, the available data do suggest that costs should be roughly comparable (order-of-magnitude) to those for utility-owned equipment on a unit basis, insofar as contamination levels and unit costs are not markedly different.

The methodology explicitly evaluates incremental inspection costs, PCB disposal costs, costs associated with the purchase and installation of new equipment, and direct costs incurred to clean up PCB spills. While the quantification of these costs is described more fully in Appendix A, five major aspects of the methodology (as it applies to cost) are described below.

1. The assessment of alternative use authorization periods requires that the natural rate of equipment retirement be estimated, since incremental effects apply only to those pieces of equipment for which retirement or PCB disposal is accelerated by mandate. No age-related data are available to describe current equipment stocks. The age profile was calculated by using previous estimates of equipment life (normally distributed) and natural failure rates, and estimating the

---

* Such costs have been conservatively estimated at over $175 billion (see the Regulatory Impact Analysis accompanying the proposed rule).

increase in the equipment stock (assumed to grow proportionately to electric kWh sales through 1977). The beginning equipment stock in 1944 was adjusted so that the 1982 stock matched the estimated population at the end of 1981.

2. Equipment is normally replaced due to failure or obsolescence. Mandating equipment replacement advances the replacement schedule that would otherwise have prevailed. The cost of such advancement is not the full replacement cost of the equipment, but rather the economic value of the equipment at the time of its phase-out. This incremental cost was estimated as the present value difference of two perpetuities of replacement that begin in different years.

3. An inherent feature of present value analysis is the requirement that the appropriate discount rate for future expenditures be known. While estimating the "social" discount rate is somewhat controversial, it could have a significant impact on results as many of the costs are attributable to timing differences, the value of which is measured by the discount rate. There are two major schools of thought in the academic literature. The first maintains that the correct social discount rate is simply the inflation rate, and hence the real discount rate is zero. The second theory is that the social discount rate for a particular project is just the private sector discount rate for a similar investment. The real rate of 3 percent used in the EEI (1982, p. A-37) study is an estimate of the private sector discount rate for investment in electrical equipment, and was adopted for this analysis as an upper-bound estimate of the proper social discount rate. The sensitivity to alternative assumptions is also measured (see Chapter 5).

4. The analysis considers aggregate costs to society, regardless of who bears them. Thus, for example, tax effects are ignored, since taxes primarily affect the distribution of costs between industry and the government, but not to society as a whole. Likewise, the opportunity for utilities to pass costs on to ratepayers via

rate increases does not affect the estimate of aggregate social costs. However, the distribution of these costs is considered in Chapter 7.

5. Finally, the methodology overstates the incremental costs of alternatives, since it does not include indirect clean-up costs (e.g., business closings) that might otherwise be incurred, or the benefits to society which may result from reduced power consumption when the removal of less efficient equipment is accelerated by mandate. An estimate of avoided direct clean-up costs (e.g., removal and disposal of contaminated soil, or dredging a nearby waterway) is incorporated in the analysis. Since PCB spills are avoided by early replacement of equipment, avoided direct clean-up costs serve to reduce the social cost calculated for each alternative. An estimate of the benefit of replacing PCB capacitors with paper or paper/ film dielectric assemblies with more efficient film type capacitors is derived separately. The sensitivity of costs to various parameter assumptions is discussed in Chapter 5.

PCB CAPACITORS

Nonsubstation Outdoor PCB Capacitors

The cost of alternative authorization periods was evaluated for nonsubstation outdoor PCB capacitors* at different levels of mandated inspection. Retrofilling capacitors is not technically feasible; secondary containment was not considered effective for this group of capacitors.

The population of nonsubstation outdoor capacitors was assumed to be equivalent to the number of nonsubstation utility-owned capacitors, estimated from the EEI (1982) study, since most nonutility-owned capacitors are located indoors. Cost data were also derived primarily from the EEI (1982) study. A 30-year average equipment life* and 3 percent real discount rate were assumed for the evaluation. A 0.4 percent per year failure rate was estimated, based on the number of reported spills (utility survey, EEI, 1982) and an estimate of the percentage of failures which spill.

---

* Almost all capacitors in this category are pole-mounted distribution capacitors.

Table 3 shows the estimated costs for each alternative, with no inspection, annual inspection, and quarterly inspection. In all cases (and for all capacitor groups), a mandated phase-out was spread evenly over the last 10 years of the phase-out period, or over the entire period (beginning in 1983**), whichever was less. Without inspection, costs range from $40.8 million for a 20-year phase-out to $187.9 million for an immediate phase-out. Inspection costs can add significantly to these totals for longer phase-out periods and more frequent inspection. A quarterly inspection program with no mandated phase-out would cost $95.0 million. Finally, on average, a 5-year phase-out with no mandated inspection would cost $120 per capacitor.

Based on discussions with General Electric, and on comments on the 22 April 1982 Proposed Rule, it was noted that changes in technology have significantly reduced the power losses associated with the new film-type capacitors, as compared to older paper or paper/film-type capacitors.

Since PCB capacitors are of the older paper or paper/film variety, an estimate of the savings in power that result from accelerated phase-out was made for the 6-year phase-out. Based on discussions with General Electric, losses on the order of 2 watts per KVAR, 0.5 watts per KVAR, and 0.1 watt per KVAR were assumed for the paper, paper/film, and film-type capacitors, respectively. The change to paper/film dielectrics was assumed to occur in 1966, followed by a change to all-film dielectrics in

---

* A 30-year life (as opposed to 25 years) was used in response to industry comments to the proposed rules. As discussed in Chapter 5, the choice of useful life is not significant.

** With the exception of the 6-year phase-out for nonsubstation outdoor capacitors and for capacitors posing a risk to food or feed, which were assumed to begin in 1984.

Table 3. 1982 Present Value Cost[a] of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors

Alternative	Cumulative Number of Units Retired Early	Cost ($ Millions) With No Mandatory Inspection	With Annual Inspection	With Quarterly Inspection
Indefinite Authorization[b]	16,415	Ref. Case	23.3	95.0
20-Year Phase-Out	605,848	40.8	N.C.	N.C.
15-Year Phase-Out	810,648	72.0	87.6	131.9
10-Year Phase-Out	1,005,076	117.3	126.6	155.2
7-Year Phase-Out	1,067,490	135.2	N.C.	N.C.
6-Year Phase-Out[c]	1,086,840	141.3	N.C.	N.C.
5-Year Phase-Out	1,105,487	147.6	153.3	170.7
Immediate Phase-Out	1,203,443	187.9	188.7	191.4

Parameters: Equipment Life = 30 ± 12 years
Failure Rate = .4 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 1,232,272 units in service, end of year 1981

[a] Cost excludes any indirect costs or credits attributable to efficiency gains with new equipment, and is reduced by avoided direct spill clean-up costs.

[b] For computational convenience, indefinite authorization was defined as authorization through the year 2030.

[c] Phase-out period 1984-1988.

N.C. = Not Calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

1979 (no PCB capacitors were manufactured after 1977). Using the methodology described in Appendix A to estimate the proportion of pre-1966 PCB capacitors still in service, and the incremental number of capacitor years of service that are lost due to a 6-year phase-out, the present value of the power savings could be calculated. Assuming distribution capacitors are energized 50 percent of the time, and that current avoided power costs average 3 cents per kWh, a savings of $105.7 million can be estimated. Since the total cost of a 6-year phase-out excluding these credits is $135.9 million, the net cost of the phase-out could be as low as $30.2 million. If the avoided cost (or marginal cost) of electricity is greater than 3 cents per kWh, or if these capacitors are energized over 50 percent of the time, the costs of the phase-out could be negative.

PCB Capacitors in Substations or Restricted Areas

The costs of six alternative use authorization periods (with and without quarterly inspection) were evaluated for PCB capacitors located in substations or restricted areas. While retrofilling is not technically feasible for capacitors, the cost to build a 20' x 20' containment area around each capacitor bank was also evaluated, assuming such containment would avoid all clean-up costs, but would require biweekly inspection of the dike. The population of substation or restricted area PCB capacitors was assumed to be equivalent to the number of substation or generating station capacitors estimated in the EEI (1982) study. A 30-year average equipment life and 3 percent real discount rate were assumed. A 0.1 percent per year failure rate was estimated based on the rate of substation spills (utility survey, EEI, 1982), the estimated percentage of failures resulting in a spill, and failure rates noted in comments to the 22 April 1982 Proposed Rule.

Table 4 shows the cost for various phase-out periods, with and without quarterly inspection. Without mandated inspection, costs range from $29.6 million for a 30-year phase-out to $543.0 million for an immediate ban. Quarterly inspection adds from $1.8 to $50.1 million, and increases as authorization period increases. The cost of secondary containment is $340.7 million -- approximately equal to the cost of a 10-year phase-out. A 5-year

Table 4. 1982 Present Value Cost[a] of Alternative PCB Regulations for PCB Capacitors Located in Substations or Restricted Areas

Alternative	Cumulative Number of Units Retired Early	Cost ($ Millions) With No Mandatory Inspection	Cost ($ Millions) With Quarterly Inspection	Cost ($ Millions) With Secondary Containment
Indefinite[b] Authorization	24,043	Ref. Case	50.1	340.7
30-Year Phase-Out	341,963	29.6	77.1	N.C.
20-Year Phase-Out	806,420	122.4	161.6	N.C.
10-Year Phase-Out	1,302,298	343.9	363.4	N.C.
5-Year Phase-Out	1,421,487	429.6	441.5	N.C.
Immediate Phase-Out	1,535,463	543.0	544.8	N.C.

Parameters: Equipment Life = 30 ± 12 years
Failure Rate = .1 percent per year
Clean-up Cost per Spill = $250

Equipment Population: 1,568,347 units in service, end of year 1981

[a] Cost excludes any indirect costs or credits attributable to efficiency gains with new equipment, and is reduced by avoided direct spill clean-up costs.

[b] For computational convenience, indefinite authorization was defined as authorization through the year 2030.

N.C. = Not Calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

phase-out without inspection would cost $274 per capacitor, on average. The credit for decreased power losses in replacement capacitors for a 5-year phase-out is estimated to be $147.8 million, a 34 percent reduction of the phase-out costs under the same assumptions as for nonsubstation capacitors.

PCB Capacitors Located Indoors or in Enclosed Areas

The costs of six alternative phase-out periods were also evaluated for PCB capacitors located indoors or in enclosed areas, again with and without quarterly inspection requirements. Retrofilling is not technically feasible. Secondary containment was not evaluated, since indoor capacitors may already be enclosed (e.g., as an integral part of a motor), since an estimate of the average number of capacitors in one bank was not available, and since the effectiveness of such containment would strongly depend on exact equipment location.

The population of indoor capacitors was assumed to be equivalent to nonutility capacitors, less those estimated to pose an exposure risk to food or feed (most nonutility-owned capacitors are used indoors). The nonutility total was estimated using EPA's assumption that utility capacitors comprise 85 percent of all large power PCB capacitors. A 30-year equipment life, a 3 percent real discount rate, and a 0.2 percent per year failure rate were assumed for the analysis, based on industry comments to the 22 April 1982 Proposed Rule, and on the comparability of these capacitors to utility-owned capacitors.

Table 5 shows the cost of each alternative phase-out period, with and without quarterly inspection. Costs range from $50.8 million (20-year phase-out) to $228 million (immediate phase-out) without inspection. Inspection adds from $0.6 million to $15.5 million, increasing with the length of the authorization period. A 5-year phase-out without inspection would cost $368 per capacitor, on average.

The credit for decreased power losses in replacement capacitors was not derived explicitly; however, the credit could be substantial and would depend on the proportion of time indoor capacitors are energized.

Table 5. 1982 Present Value Cost[a] of Alternative PCB Use Authorization for PCB Capacitors Located Indoors or in Enclosed Areas (Excluding Capacitors Posing an Exposure Risk to Food or Feed)

Alternative	Cumulative Number of Units Retired Early	Cost ($ Millions) With No Mandatory Inspection	Cost ($ Millions) Subject to Required Quarterly Inspection
Indefinite Authorization[b]	0	Ref. Case	15.5
20-Year Phase-Out	248,062	50.8	62.9
15-Year Phase-Out	328,881	98.9	98.6
10-Year Phase-Out	404,192	143.7	149.8
5-Year Phase-Out	442,298	180.0	183.7
Immediate Phase-Out	478,993	228.0	228.6

Parameters: Equipment Life = 30 ± 12 years
Failure Rate = .2 percent per year
Clean-up Cost per Spill = $250

Equipment Population: 489,654 units in service, end of year 1981

[a] Cost excludes any indirect costs or credits attributable to efficiency gains with new equipment, and is reduced by avoided direct spill clean-up costs.

[b] For computational convenience, indefinite authorization was defined as authorization through the year 2030.

N.C. = Not Calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

PCB Capacitors Posing an Exposure Risk to Food or Feed

The costs of seven alternative phase-out periods for PCB capacitors posing an exposure risk to food or feed were assessed, subject to weekly, quarterly, or no inspection. Retrofilling is not technically feasible; for the reasons stated for indoor capacitors, secondary containment was not evaluated. The total population of PCB capacitors used in food or feed industries was previously estimated by Putnam, Hayes & Bartlett (1980). EPA currently estimates that 10 percent of these capacitors pose an exposure risk to food or feed. A 30-year equipment life, 3 percent real discount rate, and a 0.1 percent per year failure rate were assumed, based on industry comments and on the comparability of these units to indoor capacitors.

Table 6 shows the cost of each alternative use authorization, subject to various inspection requirements. Without inspection, costs range from $1.46 million for a 5-year phase-out to $1.84 million for an immediate ban. Inspection adds proportionately more as the phase-out period increases. A weekly inspection program over the remaining life of the equipment would cost $950,000. A 2-year phase-out would cost $347 per capacitor, on average.

An estimate of the credit for decreased power losses in replacement capacitors was not derived explicitly; the credit could be substantial and would depend on the proportion of time these capacitors are energized.

ASKAREL TRANSFORMERS

Utility-Owned Askarel Transformers

The costs of five alternative use authorization periods, with and without quarterly inspection, were evaluated. The total costs to retrofill or construct a secondary containment dike for all of the equipment immediately were also calculated. Construction of a dike was assumed to require biweekly inspection of each dike. A retrofilling procedure was evaluated using cost data submitted from industry comments. For each accelerated phase-out program (and for all transformer groups), the

Table 6. 1982 Present Value Cost[a] of Alternative PCB Use Authorizations for PCB Capacitors Posing an Exposure Risk to Food or Feed

Alternative	Cumulative Number of Units Retired Early	Cost ($ Millions)		
		With No Mandatory Inspection	Subject to Required Quarterly Inspection	Subject to Required Weekly Inspection
Indefinite Authorization[b]	70	Ref. Case	0.08	0.95
10-Year Phase-Out	3,797	1.17	N.C.	1.54
6-Year Phase-Out	4,081	1.35[c]	N.C.	1.66
5-Year Phase-Out	4,145	1.46	1.48	1.69
3-Year Phase-Out	4,265	N.C.	N.C.	1.75
2-Year Phase-Out	4,322	1.65	1.66	1.78
Immediate Phase-Out	4,477	1.85	1.85	1.88

Parameters: Equipment Life = 30 ± 12 years
Failure Rate = .1 percent per year
Clean-up Cost per Spill = $5000

Equipment Population: 4,750 units in service, end of year 1979

[a] Cost excludes any indirect costs or credits attributable to efficiency gains with new equipment, and is reduced by avoided direct spill clean-up costs.

[b] For computational convenience, indefinite authorization was defined as authorization through the year 2030.

[c] Phase-out period 1984-1988.

N.C. = Not Calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

phase-out was spread evenly over the last ten years of the phase-out period, or over the entire phase-out, whichever was shorter.*

The population of utility-owned askarel transformers was taken from the EEI (1982) study. Based on industry comments, a 0.2 percent per year failure rate and a total 60-year equipment life (30 years new plus 30 years after one rebuild) were assumed; however, rebuilding askarel transformers was discontinued after 1975. A real discount rate of 3 percent was used.

Table 7 shows the estimated cost of various alternatives. The cost of phase-out without inspection ranges from $15.0 million for a 30-year phase-out to $621.1 million for an immediate phase-out. Quarterly inspection adds up to $28.8 million for an indefinite authorization. On average, the cost to retrofill equipment exceeds the cost to phase out all equipment immediately; however, individual cases which require large removal or installation costs could make retrofilling appear favorable. The cost to construct secondary containment around all utility-owned askarel transformers approximates the cost of a 5-year phase-out; however, the estimate depends strongly on the proportion of equipment already mounted on concrete pads, for which containment costs are much lower.

No data were available to suggest that replacement transformers differed substantially in efficiency from the askarel units they would replace; hence, no energy usage credits were calculated for any transformer group.

Nonutility-Owned Askarel Transformers

The costs of five alternative use authorization periods, subject to quarterly or no inspection requirements, were evaluated. The total cost to retrofill all units with a silicone fluid and then to filter this fluid was also estimated. The total cost to provide

---

* Except for the 3-year phase-out of askarel transformers posing an exposure risk to food or feed, where accelerated replacement was assumed to begin in 1984.

Table 7. 1982 Present Value Cost[a] of Alternative Regulations for Utility-Owned Askarel Transformers

Alternatives	Number of Units Retired Early	With No Mandatory Inspection	With Required Quarterly Inspection	With Immediate Retrofilling	With Secondary Containment
Indefinite Authorization[b]	56	Ref. Case	28.8	690.1	490.0
30-Year Phase-Out	5,142	15.0	35.3	N.C.	N.C.
20-Year Phase-Out	18,797	113.6	130.3	N.C.	N.C.
10-Year Phase-Out	32,839	379.7	388.3	N.C.	N.C.
Immediate Phase-Out	38,830	621.1	621.9	N.C.	N.C.

Parameters: Equipment Life = 30 new; 30 years rebuilt
Failure Rate = .2 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 39,640 units in service, end of year 1981

[a] Excluding indirect costs. Cost is reduced by avoided direct spill clean-up costs.

[b] For computational convenience, indefinite authorization was defined as authorization through the year 2030.

N.C. = Not Calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

secondary containment for all units was not calculated; however, it would depend strongly on the proportion of transformers already mounted on concrete pads. The population of nonutility askarel transformers was derived by assuming that utilities own 30 percent of all askarel transformers. Those transformers posing an exposure risk to food or feed were then subtracted from the nonutility total. Based on industry comments and comparability to utility-owned askarel transformers, a total 60-year equipment life and a 0.25 percent per year failure rate were assumed, as well as a 3 percent real discount rate.

Table 8 presents the cost of each alternative evaluated. Without inspection, phase-out costs range from $37 million for a 30-year phase-out to $1,554 million for an immediate phase-out. As before, inspection costs increase with longer phase-out periods, reaching $47.9 million for an indefinite authorization. In total, the cost to retrofill all units exceeds all other options; however, individual cases which require very large removal and installation costs could make this option preferable (see Chapter 5 for a more detailed discussion).

Askarel Transformers Posing an Exposure Risk to Food or Feed*

The costs of eight alternative use authorization periods subject to weekly or no required inspection were evaluated. The total cost to retrofill all of these transformers were evaluated. The total cost to construct secondary containment for all of them was not explicitly calculated; however, it would depend strongly on the number of these transformers already mounted on concrete pads.

---

* By this rule, EPA is also requiring phase-out of askarel electromagnets posing an exposure risk to food or feed by 1986. These units are similar in PCB content to askarel transformers; however, estimates of the number of askarel electromagnets currently in use or the number of those units posing an exposure risk to food or feed are not available. Since only one askarel electromagnet was reported in the EEI (1982, p. 109) survey, EPA estimates that the number posing an exposure risk to food or feed is very small. Accordingly, explicit analysis of askarel electromagnets has not been performed.

Table 8. 1982 Present Value Cost[a] of Alternative Regulations for
Nonutility-Owned Askarel Transformers
(Excluding Those Posing an Exposure Risk to Food or Feed)

Alternative	Number of Units Retired Early	Cost ($ Millions)		
		With No Mandatory Inspection	With Required Quarterly Inspection	With Immediate Retrofilling
Indefinite Authorization[b]	126	Ref. Case	47.9	1649.4
30-Year Phase-Out	11,717	37.0	83.9	N.C.
20-Year Phase-Out	43,123	281.4	321.0	N.C.
10-Year Phase-Out	75,669	947.9	967.7	N.C.
Immediate Phase-Out	89,690	1554.0	1555.8	N.C.

Parameters: Equipment Life = 30 new; 30 years rebuilt
Failure Rate = .25 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 91,597 units in service, end of year 1979

[a] Excluding indirect costs. Cost is reduced by avoided direct spill clean-up costs.

[b] For computational convenience, indefinite authorization was defined as authorization through the year 2030.

N.C. = Not Calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

The total population of askarel transformers used by food or feed industries was previously estimated by Putnam, Hayes & Bartlett (1980). EPA currently estimates that 10 percent of these transformers pose an exposure risk to food or feed. Based on industry comments, a 0.2 percent per year failure rate, and a total 60-year average life were assumed. A 3 percent real discount rate was also assumed.

Table 9 shows the cost of alternative regulations for askarel transformers posing an exposure risk to food or feed. With no required inspection, phase-out costs range from $9.77 million (10-year phase-out) to $15.98 million (immediate phase-out). Weekly inspection adds up to $6.4 million, but costs less for shorter phase-out periods. On average the cost to retrofill these transformers slightly exceeds all other alternatives; however, in certain cases, equipment removal and installation could make retrofilling appear more attractive (see discussion in Chapter 5).

MINERAL OIL TRANSFORMERS

Utility-Owned PCB and PCB-Contaminated Mineral Oil Transformers

The costs of five alternative phase-out periods for utility-owned mineral oil transformers containing greater than 50 ppm PCB were evaluated without mandatory inspection; three alternatives were evaluated with required annual inspection. Phase-out costs were assumed to require individual testing of all mineral oil transformers in order to identify those containing greater than 50 ppm PCB; for indefinite authorization, batch fluid testing was permitted. The equipment population was based on the number of units identified in the EEI (1982) study (about 20 million units, of which about 11 percent contain greater than 50 ppm PCB). Based on industry comments, a 60-year total equipment life and a 0.2 percent per year failure rate were assumed. A 3 percent real discount rate was assumed.

Table 10 presents the costs of each alternative. Without inspection, costs range from $3.7 billion for a 30-year phase-out to $7.7 billion for an immediate phase-out. For an immediate phase-out, over 80 percent of

Table 9. 1982 Present Value Cost[a] of Alternative Regulations for Askarel Transformers Posing an Exposure Risk to Food or Feed

Alternative	Cumulative Number of Units Retired Early	Cost ($ Millions) With No Mandatory Inspection	Cost ($ Millions) Subject to Required Weekly Inspection	Cost ($ Millions) With Mandatory Retrofilling
Indefinite Authorization[b]	1	Ref. Case	6.40	16.91
10-Year Phase-Out	777	9.77	12.41	N.C.
7-Year Phase-Out	823	11.34	13.37	N.C.
6-Year Phase-Out	837	11.89	13.71	N.C.
5-Year Phase-Out	851	12.44	14.05	N.C.
3-Year Phase-Out	876	13.57	14.41[c]	N.C.
2-Year Phase-Out	887	14.16	15.11	N.C.
Immediate Phase-Out	918	15.98	16.22	N.C.

Parameters: Equipment Life = 30 new; 30 years rebuilt
Failure Rate = .2 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 958 units in service, end of year 1979

[a] Excluding indirect costs. Cost is reduced by avoided direct spill clean-up costs.

[b] For computational convenience, indefinite authorization was defined as authorization through the year 2030.

[c] Phase-out period 1984-1988.

N.C. = Not Calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 10. 1982 Present Value Cost[a] of Alternative Regulations for Utility-Owned Mineral Oil Filled Transformers Containing More than 50 ppm PCB

Alternative	Number of Units Retired Early	Cost ($ Millions)	
		With No Mandatory Inspection	With Required Annual Inspection
Indefinite Authorization[b]	3,358	Ref. Case	2,657
30-Year Phase-Out	309,495	3,736	N.C.
20-Year Phase-Out	1,131,427	4,383	6,574
10-Year Phase-Out	1,976,668	6,159	N.C.
Immediate Phase-Out	2,337,307	7,736	7,837

Parameters: Equipment Life = 30 years new; 30 years rebuilt
Failure Rate = .2 percent per year
Clean-up Cost per Spill = $250

Equipment Population: 2,386,077 units in service, end of year 1981

[a] Excluding indirect costs.

[b] For computational convenience, indefinite authorization was defined as authorization through the year 2030.

N.C. = Not Calculated.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

this cost is attributable to identification of contaminated equipment. Annual inspection would cost over $2.6 billion over the remaining life of all contaminated mineral oil transformers. Retrofilling and secondary containment costs were not evaluated.

OTHER PCB-CONTAINING MINERAL OIL EQUIPMENT

In addition to nonutility-owned mineral oil transformers, four other types of mineral oil filled equipment have been identified (either in the EEI 1982 study or in comments to the 22 April 1982 Proposed Rule) as containing levels of PCB contamination comparable to those found in utility-owned mineral oil transformers: oil-filled electromagnets, switches and sectionalizers, oil-filled motor starters, and voltage regulators. While lack of data precluded an explicit analysis of regulatory alternatives for this equipment, phase-out alternatives would be dominated by the cost of identifying contaminated equipment, insofar as this equipment is comparable to mineral oil transformers on a unit basis.

Moreover, three additional equipment groups were identified as containing still lower PCB levels with almost none of the equipment contaminated to levels above 50 ppm: circuit breakers, oil-filled cables, and reclosers. Likewise, the cost of phase-out alternatives for this equipment would be dominated by the cost to identify those units contaminated to levels above 50 ppm; however, lack of data precluded an explicit analysis of these costs.

The benefit of regulating the use of PCBs in electrical equipment is the injury to health or the environment that is avoided as a result of regulation. Such injuries include the human health effects of direct or environmental exposure to PCBs, exposure to toxic derivatives of PCBs that can be avoided by regulating PCB use, health effects on plant or animal life, nonhealth effects (e.g., the loss of recreational use of contaminated waterways). The benefit of avoiding these injuries is extremely difficult to evaluate, both in terms of the magnitude of these effects and the value society places on avoiding them.

While it would clearly be useful to quantify these benefits in dollar terms, both in order to compare costs and benefits and to compare the benefits of alternative rules on a consistent basis, neither a dollar measure of value nor a direct measure of health effects (e.g., increased cancer incidence) could be determined with available data. In order to provide some measure of benefits, the cumulative weight of PCB spills or leaks that would be avoided with each alternative rule was calculated for each of the equipment categories. However, it should be cautioned that while avoided PCB release provides a consistent basis for assessing the relative benefits of alternative rules for a given equipment group, comparisons among groups must account for possible differences in PCB exposure that could be attributed to differences in equipment location. The equipment groups for which PCB release was quantified include the following:

- PCB capacitors
    - -- Nonsubstation outdoor PCB capacitors;
    - -- PCB capacitors located in substations or restricted areas;
    - -- PCB capacitors located indoors or in enclosed areas;
    - -- PCB capacitors posing an exposure risk to food or feed;
- Askarel transformers
    - -- Utility-owned askarel transformers;
    - -- Nonutility-owned askarel transformers;
    - -- Askarel transformers posing an exposure risk to food or feed;
- Mineral oil transformers
    - -- Utility-owned mineral oil filled transformers.

Two other equipment groups could not be evaluated quantitatively due to lack of data; however, since the PCB concentration levels in these equipment types is less than or equal to utility-owned mineral oil transformers, and since the number of equipment pieces is small compared to the number of mineral oil transformers, the total PCB release that can be expected to result from an indefinite authorization of all of the equipment can be safely assumed to be extremely small. These groups include:

- Switches (including sectionalizers and motor starters), mineral oil electromagnets, voltage regulators; and
- Circuit breakers, reclosers, oil-filled cables.

Contamination levels above 50 ppm have not been noted in the latter equipment group.

PCB CAPACITORS

Nonsubstation Outdoor PCB Capacitors

Table 11 shows the cumulative PCB release due to spills or leaks from nonsubstation outdoor PCB capacitors, evaluated for each phase-out option discussed in Chapter 3. Possible reductions in the number of spills that may result from inspection were not quantified; however, industry comments suggest that inspection of capacitors would not tend to reduce spills or leaks, since most failures occur without warning, and most of the PCB releases result from ruptures associated with equipment failure. Inspection could possibly serve to reduce exposure to PCBs that have already spilled, insofar as they reduce the average time before a spill is detected; however, the value of such a program cannot be quantified using a pounds-based, as opposed to an exposure-based, methodology.

Cumulative PCB releases range from 41,000 pounds for an immediate phase-out (by the end of 1982) to 771,000 pounds for an indefinite authorization. The latter figure -- 771,000 pounds -- represents about 2 percent of the total weight of PCBs currently contained in these capacitors. These estimates assume 0.4 percent of the capacitors fail per year, 48.5 percent of these failures result in a spill, and on average 55 percent of the contained fluid is lost during a spill. These values are based upon EEI's utility survey (1982), industry comments and private discussions with utilities, and hence, represent the best available data; however, they are still highly uncertain. A sensitivity analysis of these parameters is discussed in Chapter 5.

PCB Capacitors Located in Substations or Restricted Areas

Table 12 shows the cumulative PCB release resulting from spills or leaks of PCB capacitors located in substations or restricted areas for each alternative considered in Chapter 3. As before, possible reductions in spills or leaks attributable to various inspection programs were not quantified. Cumulative PCB releases range from 2,242 pounds for an immediate phase-out (end of

Table 11. Total Cumulative Weight of PCBs Spilled or Leaked From Nonsubstation Outdoor PCB Capacitors Under Alternative Regulatory Options

Alternative	Cumulative PCB Release (Pounds)
Indefinite authorization	771,291
20-year phase-out	550,791
15-year phase-out	423,271
10-year phase-out	262,371
7-year phase-out	202,051
6-year phase-out[a]	199,037
5-year phase-out	161,831
Immediate phase-out	41,181

Parameters:
Failure rate = .4 percent per year
Percentage of failures that spill = 48.5 percent
Rate of leakage without failure = .75 percent per year
Fraction of contained fluid lost per spill = .55
Fraction of contained fluid lost per leak = .01

[a] Phase-out period 1984-1988.

SOURCE: Putnam, Hayes & Bartlett, Inc. using data sources and methodology described in Appendix A.

Table 12. Total Cumulative Weight of PCBs Spilled or Leaked From PCB Capacitors Located in Substations or Restricted Areas Under Alternative Regulatory Options

Alternative	Cumulative PCB Release (Pounds)
Indefinite authorization	43,315
30-year phase-out	39,371
20-year phase-out	30,475
10-year phase-out	14,317
5-year phase-out	8,828
Immediate phase-out	2,242
Indefinite Authorization with Secondary Containment	2,653

Parameters:
Failure rate = .1 percent per year
Percentage of failures that spill = 8.3 percent
Rate of leakage without failure = .79 percent per year
Fraction of contained fluid lost per spill = .55
Fraction of contained fluid lost per leak = .01

SOURCE: Putnam, Hayes & Bartlett, Inc. using data sources and methodology described in Appendix A.

1982) to 43,315 pounds for an indefinite authorization. While secondary containment would not reduce spills or leaks per se, it was assumed to be 99 percent effective in containing such spills or leaks from release to the environment. Under an indefinite authorization, the expected release of 43,315 pounds would represent about 0.09 percent of the PCB fluid currently contained in substation capacitors. Compared to nonsubstation capacitors, this lower percentage reflects the combined effect of a lower assumed failure rate (0.1 percent per year) and a smaller fraction of failures that result in a spill (8.3 percent). These parameters were estimated from data collected in the EEI utility survey (1982) and represent the most reliable data available; however, the product of these values could vary by an order-of-magnitude.

PCB Capacitors Located Indoors or in Enclosed Areas

Table 13 shows the cumulative PCB release resulting from spills or leaks of PCB capacitors located indoors or in enclosed areas, for each of the six phase-out alternatives considered in Chapter 3. As before, the effectiveness of inspection in reducing spills was not quantified; however, it is unlikely that inspection could reduce PCB spills or leaks from capacitors significantly.

Cumulative total PCB releases range from 1,420 pounds for immediate phase-out (by the end of 1982) to 27,148 pounds for an indefinite authorization. These releases represent up to 24 percent of the PCBs currently contained in indoor capacitors.

The calculation of PCB releases for indoor capacitors reflects an assumed failure rate of 2 percent per year, a percentage of failures resulting in spills of 25 percent, and an assumed loss per spill of 25 percent of the contained fluid volume. These assumptions are based on industry comments and on the comparability of indoor capacitors to outdoor substation or nonsubstation capacitors; nevertheless, they are highly uncertain.

Table 13. Total Cumulative Weight of PCBs Spilled or Leaked from PCB Capacitors Located Indoors or in Enclosed Areas Under Alternative Regulatory Options

Alternative	Cumulative PCB Release (Pounds)
Indefinite authorization	27,148
20-year phase-out	19,196
15-year phase-out	14,693
10-year phase-out	9,060
5-year phase-out	5,587
Immediate phase-out	1,420

Parameters:
Failure rate = .2 percent per year
Percentage of failures that spill = 25 percent
Rate of leakage without failure = .75 percent per year
Fraction of contained fluid lost per spill = .25
Fraction of contained fluid lost per leak = .01

SOURCE: Putnam, Hayes & Bartlett, Inc. using data sources and methodology described in Appendix A.

PCB Capacitors Posing an Exposure Risk to Food or Feed

Table 14 shows the cumulative PCB release resulting from spills or leaks of PCB capacitors posing an exposure risk to food or feed, for each of seven phase-out periods evaluated in Chapter 3. The effectiveness of inspection in reducing spills or leaks was not quantified.

Cumulative total PCB releases range from 7 pounds for immediate phase-out to 128 pounds for an indefinite authorization. These releases represent up to 0.12 percent of the PCB fluid currently contained in capacitors posing an exposure risk to food or feed.

The calculations of PCB releases for capacitors posing an exposure risk to food or feed reflect an assumed failure rate of 0.1 percent per year, a percentage of failures resulting in spills of 25 percent, and an assumed loss per spill of 25 percent of the contained fluid volume. These assumptions are based on industry comments and the comparability of these units to indoor PCB capacitors; nevertheless, they are highly uncertain.

ASKAREL TRANSFORMERS

Utility-Owned Askarel Transformers

Table 15 shows the cumulative PCB release resulting from spills or leaks of utility-owned askarel transformers, for each of seven regulatory options considered in Chapter 3. While inspection may serve to reduce the volume of fluid lost by spills or leaks, either by earlier detection of a continuing leak or by detection of incipient failure, available data do not permit the effectiveness of inspection to be assessed quantitatively.

Cumulative total PCB releases range from 17,792 pounds (immediate phase-out) to 315,264 pounds for indefinite authorization, representing up to 0.42 percent of the PCBs currently contained in utility askarel transformers. Retrofilling an askarel transformer was assumed to reduce average PCB concentration to less than 10,000 ppm, thus reducing spills by 99 percent to 20,777 pounds (assuming retrofilling is complete by the end of

Table 14. Total Cumulative Weight of PCBs Spilled or Leaked From PCB Capacitors Posing an Exposure Risk to Food or Feed Under Alternative Regulatory Options

Alternative	Cumulative PCB Release (Pounds)
Indefinite authorization	128
10-year phase-out	42
6-year phase-out[a]	32
5-year phase-out	26
3-year phase-out	20
2-year phase-out	16
Immediate phase-out	7

Parameters:
Failure rate = .1 percent per year
Percentage of failures that spill = 25 percent
Rate of leakage without failure = .78 percent per year
Fraction of contained fluid lost per spill = .25
Fraction of contained fluid lost per leak = .01

[a] Phase-out period 1984-1988.

SOURCE: Putnam, Hayes & Bartlett, Inc. using data sources and methodology described in Appendix A.

Table 15. Total Cumulative Weight of PCBs Spilled or Leaked From Utility-Owned Askarel Transformers Under Alternative Regulatory Options

Alternative	Cumulative PCB Release (Pounds)
Indefinite authorization	315,264
30-year phase-out	302,433
20-year phase-out	240,866
10-year phase-out	113,646
Immediate phase-out	17,792
Indefinite authorization with immediate retrofill of all units	20,777
Indefinite authorization with secondary containment of all units	20,777

Parameters:
Failure rate = .2 percent per year
Percentage of failures that spill = 47.7 percent
Rate of leakage without failure = .72 percent per year
Fraction of contained fluid lost per spill = .25
Fraction of contained fluid lost per leak = .005

SOURCE: Putnam, Hayes & Bartlett, Inc. using data sources and methodology described in Appendix A.

1982). Likewise, while the effectiveness of secondary containment is probably not equivalent to phase-out or retrofilling, a 99 percent effective reduction in spills to the environment was assumed, so that 20,777 pounds would be released if all units were contained by the end of 1982.

Calculations of PCB releases from utility askarel transformers assumed a failure rate of 0.2 percent per year, a percentage of failures that spill of 47.7 percent, and a loss per spill of 25 percent of the contained fluid volume. As before, these estimates were based on utility survey data (EEI, 1982) and industry comments, but are highly uncertain.

Nonutility-Owned Askarel Transformers

Table 16 shows the cumulative PCB release resulting from spills or leaks of nonutility askarel transformers, excluding askarel transformers posing an exposure risk to food or feed, for each of six regulatory alternatives evaluated in Chapter 3. While inspection may serve to reduce fluid lost in spills or leaks, the effectiveness of inspection was not assessed quantitatively in terms of spill reduction.

Cumulative total PCB releases range from 56,354 pounds for an immediate phase-out (complete by the end of 1982) to 994,338 pounds for an indefinite authorization, representing up to 0.50 percent of the fluid currently contained in nonutility askarel transformers. As for utility askarel transformers, retrofilling was assumed to reduce PCBs spilled by 99 percent, to 65,734 pounds, assuming all retrofills are complete by the end of 1982.

Calculations of PCB releases from utility askarel transformers assumed a failure rate of 0.25 percent per year, a percentage of failures that spill of 45 percent, and a loss of 25 percent of the contained fluid per spill. These estimates are based on industry comments and comparability among askarel transformer groups; however, they are highly uncertain.

Askarel Transformers Posing an Exposure Risk to Food or Feed

Table 17 shows the cumulative PCB release resulting from spills or leaks of askarel transformers posing an

Table 16. Total Cumulative Weight of PCBs Spilled or Leaked From Nonutility-Owned Askarel Transformers (Excluding Units Posing an Exposure Risk to Food or Feed) Under Alternative Regulatory Options

Alternative	Cumulative PCB Release (Pounds)
Indefinite authorization	994,338
30-year phase-out	954,336
20-year phase-out	761,021
10-year phase-out	359,847
Immediate phase-out	56,354
Indefinite authorization with immediate retrofill of all units	65,734

Parameters:
Failure rate = .25 percent per year
Percentage of failures that spill = 45 percent
Rate of leakage without failure = 1.5 percent per year
Fraction of contained fluid lost per spill = .25
Fraction of contained fluid lost per leak = .005

SOURCE: Putnam, Hayes & Bartlett, Inc. using data sources and methodology described in Appendix A.

Table 17. Total Cumulative Weight of PCBs Spilled or Leaked From Askarel Transformers Posing an Exposure Risk to Food or Feed Under Alternative Regulatory Options

Alternative	Cumulative PCB Release (Pounds)
Indefinite authorization	8,668
10-year phase-out	3,125
7-year phase-out	2,406
6-year phase-out	2,166
5-year phase-out	1,927
3-year phase-out[a]	1,671
2-year phase-out	1,208
Immediate phase-out	489
Indefinite authorization with immediate retrofill of all units	571

Parameters:
Failure rate = .2 percent per year
Percentage of failures that spill = 47.7 percent
Rate of leakage without failure = .72 percent per year
Fraction of contained fluid lost per spill = .25
Fraction of contained fluid lost per leak = .005

[a] Phase-out period 1984-1988.

SOURCE: Putnam, Hayes & Bartlett, Inc. using data sources and methodology described in Appendix A.

exposure risk to food or feed, for each of the nine regulatory options considered in Chapter 3.* The effectiveness of inspection programs was not quantified.

Cumulative total PCB releases range from 489 pounds under an immediate phase-out (completed by the end of 1982) to 8,668 pounds under an indefinite authorization, and represent up to 0.41 percent of the fluid currently contained in this equipment. Assuming that retrofilling is 99 percent effective, a program to retrofill all units by the end of 1982 would reduce PCB releases to 571 pounds over the remaining life of the equipment.

The PCB release calculations were based on a failure rate of 0.2 percent per year, a percentage of failures that spill of 47.7 percent, and a loss of 25 percent of the contained fluid per spill. These parameters are highly uncertain. A sensitivity analysis is presented in Chapter 5.

MINERAL OIL TRANSFORMERS

Utility-Owned PCB and PCB-Contaminated Mineral Oil Transformers

Table 18 presents the weight of PCBs lost in spills or leaks from utility PCB-containing mineral oil transformers, for which the estimated PCB concentration is above 50 ppm. The expected release for each of five regulatory options is evaluated. The effectiveness of inspection programs was not quantified.

Despite a very large number of utility mineral oil transformers, spills or leaks above 50 ppm would release from 51 pounds for an immediate phase-out to 908 pounds for indefinite authorization. The amount of 908 pounds represents 0.26 percent of the PCBs currently contained in

---

* Based on industry comments, EPA estimates that a small number of askarel electromagnets currently pose an exposure risk to food or feed. While spills from this equipment have not been estimated, the leak and volume characteristics are believed to be similar to those for askarel transformers.

Table 18. Total Cumulative Weight of PCBs Spilled or Leaked From Utility-Owned PCB and PCB-Contaminated Mineral Oil Transformers Under Alternative Regulatory Options

Alternative	Cumulative PCB Release (Pounds)
Indefinite authorization	908
30-year phase-out	871
20-year phase-out	694
10-year phase-out	327
Immediate phase-out	51

Parameters:
Failure rate = .2 percent per year
Percentage of failures that spill = 47.7 percent
Rate of leakage without failure = .72 percent per year
Fraction of contained fluid lost per spill = .25
Fraction of contained fluid lost per leak = .005
Average PCB concentration = 280 ppm

SOURCE: Putnam, Hayes & Bartlett, Inc. using data sources and methodology described in Appendix A.

this equipment. These calculations assumed a 0.2 percent per year failure rate, a 47.7 percentage of failures that spill, and a loss per spill of 25 percent of the contained unit volume. These data are based primarily on utility survey results (EEI, 1982) and industry comments, but are nevertheless highly uncertain.

OTHER PCB-CONTAINING MINERAL OIL EQUIPMENT

As reported by EEI (p. 10, III, 1982), other utility-owned electrical equipment may contain about 20,000 pounds of PCBs. If the total population of utility and nonutility mineral oil filled electrical equipment contained as much as 100,000 pounds of PCBs, only 260 pounds of PCBs would be spilled by indefinite authorization of the equipment, assuming that leakage and spill characteristics are comparable to those for utility mineral oil transformers.

EVALUATING COSTS AND BENEFITS CHAPTER 5

The present value of net costs to society and the total PCB release resulting from various regulatory alternatives for PCB-containing electrical equipment have been presented in Chapters 3 and 4. In order to choose among alternatives (which include no regulation -- essentially an indefinite use authorization without restrictions), it is necessary to derive some measure of the net benefits to society that would accrue from each alternative. Ideally, EPA should then choose the set of alternatives which maximize net social benefits, provided that these alternatives are feasible and that no single sector of the economy would bear unreasonable costs.

In the absence of a quantitative measure of benefits, an alternative means of comparison was necessary. Using the cumulative weight of avoided PCB releases as a relative measure of benefits, a cost-effectiveness ratio was calculated, which measures the present value of social costs incurred to avoid a pound of PCB release under each regulatory alternative. The cost-effectiveness ratios can then be used to identify those alternatives that would yield positive net benefits, by estimating implicitly or explicitly the average benefit to society of each pound of PCB release avoided.

Two shortcomings of the cost-effectiveness measure should be mentioned. First, the ratios cannot always be used to compare mutually exclusive alternatives for a given equipment category which both may produce positive net benefits (for example, phase-out and secondary containment). This problem results because comparison of cost-effectiveness ratios cannot account for differences in the magnitude of PCB release, so that choosing the alternative with a lower cost per pound may not maximize net benefits. This is not an issue when comparing two different phase-out periods, as the shorter period can be assessed on a marginal basis.* As a practical matter, however, the differences between marginal and average cost-effectiveness are dwarfed by uncertainty in the underlying data.

The cost-effectiveness estimates for alternatives other than phase-out are similarly imprecise. Given this uncertainty, cost-effectiveness ratios provide an order-of-magnitude estimate which can be useful in determining whether any alternative to indefinite authorization should be selected. Once this determination has been made, an alternative method, such as maximizing the PCB release avoided subject to manufacturing and disposal capacity constraints, must be used to choose among alternatives.

The second shortcoming of the cost-effectiveness measure arises because the benefit to society of avoiding PCB releases differs depending on where and how the PCBs are lost to the environment. Such differences are ultimately attributable to variations in the risk of injury to health and the environment. For example, the benefit of avoiding a pound of PCB release from equipment used in food or feed industries is probably greater than the benefit of avoiding losses from equipment in restricted utility substations. At present, data are not available to permit a quantitative distinction among PCB exposure risks for different equipment classes; such distinctions must be made judgmentally. Accordingly, a comparison of cost-effectiveness ratios among different equipment classes should be performed cautiously.

---

* The figures shown in Chapters 3, 4 and 5 are calculated on an average, rather than marginal basis, in order to compare a set of discrete alternatives (including retrofilling and containment). Theoretically, however, alternative phase-out periods form a continuous set such that, other things being equal, the marginal cost to avoid an additional pound of PCB release increases monotonically as the phase-out period is shortened. By comparing the costs and avoided PCB release of adjacent phase-out periods, a marginal cost-effectiveness can be calculated. From the continuous set of phase-out periods, the "optimal" phase-out occurs when the cost-effectiveness equals the marginal benefit per pound avoided. In the absence of a quantitative analysis of dollar benefits, this marginal benefit per pound must be chosen by judgment.

As in Chapters 3 and 4, cost-effectiveness ratios are developed quantitatively for eight equipment groups, comprising large PCB power capacitors, askarel transformers, and utility mineral oil transformers. Two other groups of PCB-containing electrical equipment will be discussed only qualitatively due to lack of data. For a representative group of PCB capacitors and askarel transformers, a sensitivity analysis was also performed.

In general, the cost-effectiveness of regulating different equipment groups varies by nearly five orders-of-magnitude, a range well in excess of the uncertainty of the calculations. Moreover, an assessment of potential PCB exposure tends to exacerbate, rather than mitigate, these differences. Equipment phase-out is most cost-effective for nonsubstation PCB capacitors and least cost-effective for mineral oil transformers.

PCB CAPACITORS

Nonsubstation Outdoor PCB Capacitors

Tables 19, 20, and 21 present the cost-effectiveness of nonsubstation capacitor phase-out alternatives, subject to no inspection, quarterly inspection and annual inspection, respectively. With no inspection requirements, the average cost per pound of avoided PCB release increases from $185 per pound to $257 per pound as the phase-out period is decreased from 20 years to an immediate phase-out.* Note that the avoided PCB release is the decrease in PCB release measured relative to the reference case of indefinite authorization. As Table 20 illustrates, the cost-effectiveness ratio declines to $262 per pound for

---

* Excluding efficiency gains. If efficiency gains are taken into account for a 6-year phase-out, costs (and hence cost-effectiveness) approach zero.

Table 19. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors

Alternative	Conditions	Cost[a] ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
20-Year Phase-Out	No Inspection	40.79	220,500	185
15-Year Phase-Out	No Inspection	72.03	348,020	207
10-Year Phase-Out	No Inspection	117.32	508,920	231
7-Year Phase-Out	No Inspection	135.21	569,240	238
6-Year Phase-Out[b]	No Inspection	135.85	572,254	237
5-Year Phase-Out	No Inspection	147.61	609,460	242
Immediate Phase-Out	No Inspection	187.91	730,110	257

Reference Case: Indefinite authorization of nonsubstation outdoor PCB capacitors, with no mandatory inspection.

Parameters:
Equipment Life = 30 years
Failure Rate = .4 percent per year
Percent of Failures that Spill = 48.5 percent
Leak Rate (w/o Failure) = .75 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 1,232,272 units in service, end of year 1981 (assumed equivalent to nonsubstation utility-owned capacitors).

[a] Excluding efficiency savings.
[b] Phase-out period 1984-1988.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 20. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors

Alternative	Conditions	Cost[a] ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
Indefinite Authorization	Quarterly Inspection	95.03	0	∞
15-Year Phase-Out	Quarterly Inspection	131.91	348,020	379
10-Year Phase-Out	Quarterly Inspection	155.21	508,920	305
5-Year Phase-Out	Quarterly Inspection	170.71	609,460	280
Immediate Phase-Out	Quarterly Inspection	191.41	730,110	262

Reference Case: Indefinite authorization of nonsubstation outdoor PCB capacitors, with no mandatory inspection.

Parameters:
Equipment Life = 30 years
Failure Rate = .4 percent per year
Percent of Failures that Spill = 48.5 percent
Leak Rate (w/o Failure) = .75 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 1,232,272 units in service, end of year 1981 (assumed equivalent to nonsubstation utility-owned capacitors).

[a] Excluding efficiency savings.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 21. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors

Alternative	Conditions	Cost[a] ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
Indefinite Authorization	Annual Inspection	23.34	0	∞
15-Year Phase-Out	Annual Inspection	86.76	348,020	249
10-Year Phase-Out	Annual Inspection	126.61	508,920	249
5-Year Phase-Out	Annual Inspection	153.31	609,460	252
Immediate Phase-Out	Annual Inspection	188.71	730,110	258

Reference Case: Indefinite authorization of nonsubstation outdoor PCB capacitors, with no mandatory inspection.

Parameters:
Equipment Life = 30 years
Failure Rate = .4 percent per year
Percent of Failures that Spill = 48.5 percent
Leak Rate (w/o Failure) = .75 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 1,232,272 units in service, end of year 1981 (assumed equivalent to nonsubstation utility-owned capacitors).

[a] Excluding efficiency savings.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

shorter phase-out periods subject to quarterly inspection, since earlier phase-out avoids the cost of inspection in later years.

In order to assess the sensitivity of these results to uncertainty in the parameters, five separate analyses were performed. Tables 22, 23, 24, 25, and 26 show alternative estimates of cost-effectiveness for 10-year, 5-year, and immediate phase-out periods, varying average equipment life, the rate of replacement equipment cost escalation, clean-up cost per spill, real discount rate, and failure rate. The variations in each parameter were chosen to reflect the estimated uncertainty in that parameter. Varying expected equipment life from 25 to 40 years alters the cost-effectiveness by about 35 percent, independent of phase-out period; however, the cost per pound avoided tends to decline as the assumed equipment life increases, since more equipment tends to be removed by failure, with a resulting increase in the estimated weight of PCBs that leak or spill.

A phase-out of capacitors over a short period could potentially cause equipment price to rise at a faster rate than normal. Base case assumptions assumed a 9 percent rate of nominal price increase -- substantially above the average annual rate of 3 percent over the last five years (computed from NEMA statistical reports). However, if prices were to rise at a 13.4 percent annual rate through the phase-out period (returning to 9 percent thereafter), costs and cost-effectiveness ratios could increase up to 60 percent for a 10-year phase-out period. The computed impact is greatest for longer phase-out periods, since prices are assumed to begin at the same level.

Estimates of clean-up costs were derived from various industry comments describing individual clean-up incidents. Since this cost can vary dramatically depending on the individual circumstances surrounding a spill, the estimate must be viewed as highly uncertain. Varying clean-up cost by a factor of 5 would increase cost-effectiveness by up to 80 percent but could decrease it by nearly 400 percent. In fact, average clean-up costs of $12,000 to $13,000 would result in negative costs to society for capacitor phase-out, since clean-up costs are thus avoided. In such a case, capacitor owners would already have a strong incentive for voluntary PCB capacitor replacement.

Table 22. Sensitivity Analysis -- Equipment Life: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with no Mandatory Inspection

Alternative	Parameter	Cost[a] ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
10-Year Phase-Out	Life = 25	108.0	363,630	296.9
	Life = 30[b]	117.3	508,920	230.5
	Life = 40	121.3	794,300	152.7
5-Year Phase-Out	Life = 25	145.1	463,320	313.1
	Life = 30[b]	147.6	609,460	242.2
	Life = 40	143.3	895,780	160.0
Immediate Phase-Out	Life = 25	194.2	582,950	333.1
	Life = 30*	187.9	730,110	257.4
	Life = 40	172.5	101,760	169.5

[a] Excluding efficiency savings.
[b] Base Case Assumption.

Reference Case: Indefinite authorization of nonsubstation outdoor PCB capacitors, with no mandatory inspection.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 23. Sensitivity Analysis -- Capacitor Price Escalation: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with No Mandatory Inspection

Alternative	Parameter	Cost[a] ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided
10-Year Phase-Out	Capacitor Price Escalation Rate = .09[b]	117.3	508,920	230.5
	Capacitor Price Escalation Rate = .134	186.8	508,920	367.0
5-Year Phase-Out	Capacitor Price Escalation Rate = .09[b]	147.6	609,460	242.2
	Capacitor Price Escalation Rate = .134	187.3	609,460	307.3
Immediate Phase-Out	Capacitor Price Escalation Rate = .09[b]	187.9	730,110	257.4
	Capacitor Price Escalation Rate = .134	187.9	730,110	257.4

[a] Excluding efficiency savings.

[b] Base Case Assumption.

Reference Case: Indefinite authorization of nonsubstation outdoor PCB capacitors, with no mandatory inspection using a capacitor price escalation rate of 9%.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 24. Sensitivity Analysis -- Clean-Up Cost Per Spill: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with No Mandatory Inspection

Alternative	Parameter	Cost[a] ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided
10-Year Phase-Out	Clean-up Cost = $1250	208.4	508,920	409.6
	Clean-up Cost = $6000[b]	117.3	508,920	230.5
	Clean-up Cost = $30000	(343.3)	508,920	(674.6)
5-Year Phase-Out	Clean-up Cost = $1250	262.4	609,460	430.6
	Clean-up Cost = $6000[b]	147.6	609,460	242.2
	Clean-up Cost = $30000	(432.3)	609,460	(709.3)
Immediate Phase-Out	Clean-up Cost = $1250	333.9	730,110	457.4
	Clean-up Cost = $6000[b]	187.9	730,110	257.4
	Clean-up Cost = $30000	(550.1)	730,110	(753.5)

[a] Excluding efficiency savings.
[b] Base Case Assumption.

Reference Case: Indefinite authorization of nonsubstation outdoor PCB capacitors, with no mandatory inspection.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 25. Sensitivity Analysis -- Real Discount Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with No Mandatory Inspection

Alternative	Parameter	Cost[a] ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided
10-Year Phase-Out	Real Discount Rate = 1%	71.3	508,920	140.1
	Real Discount Rate = 3%[b]	117.3	508,920	230.5
	Real Discount Rate = 5%	144.9	508,920	284.8
5-Year Phase-Out	Real Discount Rate = 1%	86.8	609,460	142.4
	Real Discount Rate = 3%[b]	147.6	609,460	242.2
	Real Discount Rate = 5%	188.6	609,460	309.5
Immediate Phase-Out	Real Discount Rate = 1%	106.1	730,110	145.3
	Real Discount Rate = 3%[b]	187.9	730,110	257.4
	Real Discount Rate = 5%	250.2	730,110	342.7

[a] Excluding efficiency savings.
[b] Base Case Assumption.

Reference Case: Indefinite authorization of nonsubstation outdoor PCB capacitors, with no mandatory inspection.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 26. Sensitivity Analysis -- Failure Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Nonsubstation Outdoor PCB Capacitors with No Mandatory Inspection

Alternative	Parameter	Cost[a] ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided
10-Year Phase-Out	Failure Rate = .01	50.8	1,161,300	43.7
	Failure Rate = .004[b]	117.3	508,920	230.5
	Failure Rate = .0015	195.9	198,200	988.4
5-Year Phase-Out	Failure Rate = .01	65.1	1,411,400	46.1
	Failure Rate = .004[b]	147.6	609,460	242.2
	Failure Rate = .0015	245.0	235,980	1,038.2
Immediate Phase-Out	Failure Rate = .01	84.0	1,711.50	49.1
	Failure Rate = .004[b]	187.9	730,110	257.4
	Failure Rate = .0015	310.1	281,320	1,102.2

[a] Excluding efficiency savings.
[b] Base Case Assumption.

Reference Case: Indefinite authorization of nonsubstation outdoor PCB capacitors, with no mandatory inspection.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

The base case estimate of 3 percent for the real social discount rate was derived from the EEI (1982) study. Varying this assumption by ±2 percent changes cost-effectiveness ratios by 20 to 40 percent, with the changes being slightly greater for shorter phase-out periods (when the effect of discounting is incrementally greatest). Finally, varying the failure rate (Table 26) by a factor of 2.5 alters cost-effectiveness by 80 to 430 percent. A compound effect occurs because, at higher failure rates more spills occur, so that the cost of phase-out is decreased by greater avoided clean-up costs.

In summary, cost-effectiveness is not strongly sensitive to variations in equipment life, real discount rate, or equipment price escalation; however, uncertainty in estimated clean-up costs or in assumed failure rates could alter the calculations substantially. Similar tendencies can be assumed to hold for other PCB capacitor categories as well. Within an equipment category, uncertainty tends to exceed differences that result from varying phase-out periods.

PCB Capacitors in Substations or Restricted Areas

Tables 27 and 28 present the cost-effectiveness of alternative regulation of substation capacitors with no inspection and required quarterly inspection, respectively. Cost-effectiveness ranges from $7,506 per pound avoided for a 30-year phase-out to an average $13,220 per pound avoided for an immediate phase-out. Compared to nonsubstation capacitors, these higher cost-effectiveness ratios primarily reflect the lower assumed spill rate for this equipment. The difference probably exceeds the uncertainty in these estimates.

The cost-effectiveness of secondary containment was calculated to be $8,379 per pound avoided, assuming that it avoids 99 percent of all PCB spills. While this assumption may overestimate the effectiveness of containment, this option would have a cost-effectiveness ratio equal to or lower than that of a 5-year phase-out if it is 62 percent or more effective in reducing PCB spills, or resulting PCB exposure.

Table 27. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors in Substations or Restricted Areas

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
30-Year Phase-Out	No Inspection	29.6	3,944	7,506
20-Year Phase-Out	No Inspection	122.4	12,840	9,533
10-Year Phase-Out	No Inspection	343.9	28,998	11,860
5-Year Phase-Out	No Inspection	429.6	34,487	12,456
Immediate Phase-Out	No Inspection	543.0	41,073	13,220
Indefinite Authorization with Immediate Secondary Containment	Biweekly Dike Inspection	340.7	40,662	8,379

Reference Case: Indefinite authorization of substation capacitors, with no mandatory inspection.

Parameters: Equipment Life = 30 years
Failure Rate = .1 percent per year
Percent of Failures that Spill = 8.3 percent
Leak Rate (w/o Failure) = .79 percent per year
Clean-up Cost per Spill = $250

Equipment Population: 1,568,347 units in service, end of year 1981 (assumed equivalent to utility-owned substation capacitors).

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 28. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors in Substations or Restricted Areas

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
Indefinite Authorization	Quarterly Inspection	50.1	0	∞
30-Year Phase-Out	Quarterly Inspection	77.1	3,944	19,539
20-Year Phase-Out	Quarterly Inspection	161.6	12,840	12,587
10-Year Phase-Out	Quarterly Inspection	363.4	28,998	12,533
5-Year Phase-Out	Quarterly Inspection	441.5	34,487	12,801
Immediate Phase-Out	Quarterly Inspection	544.8	41,073	13,264

Reference Case: Indefinite authorization of substation capacitors, with no mandatory inspection.

Parameters: Equipment Life = 30 years
Failure Rate = .1 percent per year
Percent of Failures that Spill = 8.3 percent
Leak Rate (w/o Failure) = .79 percent per year
Clean-up Cost per Spill = $250

Equipment Population: 1,568,347 units in service, end of year 1981 (assumed to be equivalent to utility-owned substation capacitors).

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

PCB Capacitors Located Indoors or in Enclosed Areas

Tables 29 and 30 show the cost-effectiveness of alternative phase-out periods for indoor PCB capacitors, with no inspection and required quarterly inspection, respectively. The average cost-effectiveness of phase-out ranges from $6,384 per pound avoided for a 20-year phase-out (no inspection) to $8,864 per pound avoided for an immediate phase-out. The cost-effectiveness of these alternatives is comparable to that for substation capacitors, but is significantly greater than that for nonsubstation outdoor capacitors.

PCB Capacitors Posing an Exposure Risk to Food or Feed

Tables 31 and 32 present the cost-effectiveness of various phase-out alternatives for PCB capacitors posing an exposure risk to food or feed, for no inspection, quarterly inspection, and weekly inspection. The cost-effectiveness ranges from $14,325 per pound avoided for a 5-year phase-out without inspection to $17,917 per pound avoided for a 10-year phase-out with weekly inspection.* These ratios are higher than for other PCB capacitor groups, but significantly so only compared to nonsubstation outdoor capacitors. Moreover, the benefit of avoiding PCB releases from this category of equipment is probably greater than for other PCB capacitor groups.

ASKAREL TRANSFORMERS

Utility-Owned Askarel Transformers

Tables 33 and 34 present the cost-effectiveness of various regulatory alternatives for utility askarel transformers, with no inspection and quarterly inspection,

---

* These calculations are conservative in that they do not account for capacitors that may be relocated or contained in indoor and restricted areas at a lower cost than replacement. Hence total costs, and thus the cost per pound of PCB avoided, may be overstated.

Table 29. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors Located Indoors or in Enclosed Areas (Excluding Capacitors Posing an Exposure Risk to Food or Feed)

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
20-Year Phase-Out	No Inspection	50.8	7,952	6,384
15-Year Phase-Out	No Inspection	88.9	12,455	7,140
10-Year Phase-Out	No Inspection	143.7	18,088	7,947
5-Year Phase-Out	No Inspection	180.0	21,561	8,349
Immediate Phase-Out	No Inspection	228.0	25,728	8,864

Reference Case: Indefinite authorization of indoor PCB capacitors with no mandatory inspection (excluding capacitors posing an exposure risk to food or feed).

Parameters: Equipment Life = 30 years
Failure Rate = .2 percent per year
Percent of Failures that Spill = 25 percent
Leak Rate (w/o Failure) = .75 percent per year
Clean-up Cost per Spill = $250

Equipment Population: 489,654 units in service, end of year 1981 (assumed equivalent to nonutility-owned PCB capacitors less PCB capacitors posing an exposure risk to food or feed).

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 30. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors Located Indoors or in Enclosed Areas (Excluding Capacitors Posing an Exposure Risk to Food or Feed)

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
Indefinite Authorization	Quarterly Inspection	15.5	0	∞
20-Year Phase-Out	Quarterly Inspection	62.9	7,952	7,916
15-Year Phase-Out	Quarterly Inspection	98.6	12,455	7,917
10-Year Phase-Out	Quarterly Inspection	149.8	18,088	8,283
5-Year Phase-Out	Quarterly Inspection	183.7	21,561	8,521
Immediate Phase-Out	Quarterly Inspection	228.6	25,728	8,885

Reference Case: Indefinite authorization of indoor PCB capacitors with no mandatory inspection (excluding capacitors posing an exposure risk to food or feed).

Parameters:
Equipment Life = 30 years
Failure Rate = .2 percent per year
Percent of Failures that Spill = 25 percent
Leak Rate (w/o Failure) = .75 percent per year
Clean-up Cost per Spill = $250

Equipment Population: 489,654 units in service, end of year 1981 (assumed equivalent to nonutility-owned PCB capacitors less PCB capacitors posing an exposure risk to food or feed).

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 31. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors Posing an Exposure Risk to Food or Feed

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
10-Year Phase-Out	No Inspection	1.17	86	13,603
6-Year Phase-Out[a]	No Inspection	1.35	96	14,029
5-Year Phase-Out	No Inspection	1.46	102	14,325
2-Year Phase-Out	No Inspection	1.65	112	14,611
Immediate Phase-Out	No Inspection	1.85	121	15,265
Indefinite Authorization	Quarterly Inspection	0.08	0	∞
5-Year Phase-Out	Quarterly Inspection	1.48	102	14,503
2-Year Phase-Out	Quarterly Inspection	1.66	112	14,818

Reference Case: Indefinite authorization of PCB capacitors posing an exposure risk to food or feed, with no mandatory inspection.

Parameters:
Equipment Life = 30 years
Failure Rate = .1 percent per year
Percent of Failures that Spill = 25 percent
Leak Rate (w/o Failure) = .79 percent per year
Clean-up Cost per Spill = $5,000

Equipment Population: 4,750 units in service, end of year 1979 (estimated as 10 percent of units used by food or feed industries).

[a] Phase-Out period 1984-1988.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 32. Cost-Effectiveness of Alternative PCB Use Authorizations for PCB Capacitors Posing an Exposure Risk to Food or Feed

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
Indefinite Authorization	Weekly Inspection	0.95	0	∞
10-Year Phase-Out	Weekly Inspection	1.54	86	17,917
6-Year Phase-Out	Weekly Inspection	1.66	99	16,737
5-Year Phase-Out	Weekly Inspection	1.69	102	16,543
3-Year Phase-Out	Weekly Inspection	1.75	108	16,201
2-Year Phase-Out	Weekly Inspection	1.78	112	15,909
Immediate Phase-Out	Weekly Inspection	1.88	121	15,549

Reference Case: Indefinite authorization of PCB capacitors posing an exposure risk to food or feed, with no mandatory inspection.

Parameters: Equipment Life = 30 years
Failure Rate = .1 percent per year
Percent of Failures that Spill = 25 percent
Leak Rate (w/o Failure) = .75 percent per year
Clean-up Cost per Spill = $5,000

Equipment Population: 4,750 units in service, end of year 1979 (estimated as 10 percent of units used by food or feed industries).

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 33. Cost-Effectiveness of Alternative PCB Use Authorizations for Utility-Owned Askarel Transformers

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
30-Year Phase-Out	No Inspection	15.0	12,831	1,168.0
20-Year Phase-Out	No Inspection	113.6	74,398	1,521.0
10-Year Phase-Out	No Inspection	379.7	201,618	1,883.4
Immediate Phase-Out	No Inspection	621.1	297,472	2,088.1
Indefinite Authorization with Immediate Retrofill	No Inspection	690.0	294,947	2,343.0
Indefinite Authorization with Secondary Containment	Biweekly Dike Inspection	490.0	294,497	1,664.0

Reference Case: Indefinite authorization of utility-owned askarel transformers with no mandatory inspection.

Parameters: Equipment Life = 30 years new; 30 years rebuilt
Failure Rate = .2 percent per year
Percent of Failures that Spill = 47.7 percent
Leak Rate (w/o Failure) = .72 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 39,640 units in service, end of year 1981.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 34. Cost-Effectiveness of Alternative PCB Use Authorizations for Utility-Owned Askarel Transformers

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
Indefinite Authorization	Quarterly Inspection	28.8	0	∞
30-Year Phase-Out	Quarterly Inspection	35.3	12,831	2,753.7
20-Year Phase-Out	Quarterly Inspection	130.3	74,398	1,751.9
10-Year Phase-Out	Quarterly Inspection	388.3	201,618	1,925.5
Immediate Phase-Out	Quarterly Inspection	621.9	297,472	2090.7

Reference Case: Indefinite authorization of utility-owned askarel transformers with no mandatory inspection.

Parameters: Equipment Life = 30 years new; 30 years rebuilt
Failure Rate = .2 percent per year
Percent of Failures that Spill = 47.7 percent
Leak Rate (w/o Failure) = .72 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 39,640 units in service, end of year 1981.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

respectively. Cost-effectiveness ranges from $1,168 per pound avoided for a 30-year phase-out without inspection to $2,754 per pound avoided for a 30-year phase-out with quarterly inspection. This range falls between nonsubstation outdoor PCB capacitors and other capacitor classes.

The cost-effectiveness of retrofilling was estimated to be $2,343 per pound avoided, which exceeds all phase-out options without mandatory inspection. Conversely, secondary containment is comparable in cost-effectiveness to a 20-year phase-out. In order for the cost-effectiveness of secondary containment and retrofilling to be comparable, the unit cost to contain a unit would have to amount to $12,758. Using EEI assumptions (1982), this would represent average costs if 88 percent of all utility askarel transformers were not currently pad-mounted (as opposed to the base case 50 percent assumption).

Nonutility-Owned Askarel Transformers

Tables 35 and 36 present the cost-effectiveness of various regulatory alternatives for nonutility askarel transformers, subject to no inspection or quarterly inspection, respectively. Cost-effectiveness without inspection ranges from $926 per pound avoided to $1,657 per pound avoided for phase-out in 30 years down to immediate phase-out. These values are comparable to those for utility-owned askarel transformers.

The cost-effectiveness of retrofilling was estimated to be $1,776 per pound avoided -- in excess of all options except a 30-year phase-out with quarterly inspection. While the unit cost to contain this equipment was not available, a cost of up to $14,692 per transformer could be incurred before retrofilling would be preferred to containment, assuming both options are equally effective in avoiding PCB releases. This "breakeven" containment cost is even higher than the cost of containing nonpad-mounted transformers, according to EEI (1982) estimates.

Table 35. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonutility-Owned Askarel Transformers (Excluding Transformers Posing an Exposure Risk to Food or Feed)

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
30-Year Phase-Out	No Inspection	37.0	40,002	926.0
20-Year Phase-Out	No Inspection	281.4	233,317	1,206.2
10-Year Phase-Out	No Inspection	947.9	634,491	1,493.9
Immediate Phase-Out	No Inspection	1,554.0	937,984	1,656.7
Indefinite Authorization with Immediate Retrofill	No Inspection	1,649.4	928,604	1,776.0

Reference Case: Indefinite authorization of utility-owned askarel transformers with no mandatory inspection (excluding transformers posing an exposure risk to food or feed).

Parameters: Equipment Life = 30 years new; 30 years rebuilt
Failure Rate = .25 percent per year
Percent of Failures that Spill = 45 percent
Leak Rate (w/o Failure) = 1.5 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 91,597 units in service, end of year 1981.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 36. Cost-Effectiveness of Alternative PCB Use Authorizations for Nonutility-Owned Askarel Transformers
(Excluding Transformers Posing an Exposure Risk to Food or Feed)

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
Indefinite Authorization	Quarterly Inspection	47.9	0	∞
30-Year Phase-Out	Quarterly Inspection	83.9	40,002	2,097.0
20-Year Phase-Out	Quarterly Inspection	321.0	233,317	1,375.9
10-Year Phase-Out	Quarterly Inspection	967.7	634,491	1,525.2
Immediate Phase-Out	Quarterly Inspection	1,555.8	937,984	1,658.7

Reference Case: Indefinite authorization of utility-owned askarel transformers with no mandatory inspection (excluding transformers posing an exposure risk to food or feed)

Parameters: Equipment Life = 30 years new; 30 years rebuilt
Failure Rate = .25 percent per year
Percent of Failures that Spill = 45 percent
Leak Rate (w/o Failure) = 1.5 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 91,597 units in service, end of year 1981.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Askarel Transformers Posing an Exposure Risk to Food or Feed

Tables 37 and 38 present the cost-effectiveness of various regulatory options for askarel transformers posing an exposure risk to food or feed, with required weekly inspection or no inspection, respectively. The cost-effectiveness ranges from $1,762 per pound avoided for a 10-year phase-out without inspection to $2,238 per pound avoided for a 10-year phase-out with weekly inspection.* The range is comparable to values for other transformer groups; however, the benefit of avoiding PCB spills from this group may be greater. As with nonsubstation capacitors, under a weekly inspection requirement, the cost-effectiveness ratios decrease as the phase-out period is shortened, rather than increasing as is the case with no inspection requirement.

The cost-effectiveness ratio of an immediate retrofill program is $2,080 per pound avoided, comparable to a 5-year phase-out with required weekly inspection (assuming retrofill avoids required inspection). In order for this cost-effectiveness to fall below a 2-year phase-out with weekly inspection, the individual cost to remove and install a transformer would have to be only 8 percent higher than average. In order for containment to be as cost-effective as retrofilling, average containment costs could be as much as $14,685 per transformer, assuming containment and retrofilling are equally effective in reducing PCB releases. Using EEI (1982) containment costs, containment would be cheaper even if none of the transformers were already pad-mounted.

As for PCB nonsubstation outdoor capacitors, the sensitivity of cost-effectiveness to alternative major parameter assumptions was explored. These calculations are shown in Tables 39, 40, 41, 42, and 43. The sensitivity to equipment age assumptions ranging from 40 to 80 years is less than 30 percent; cost-effectiveness decreases with increased life, as was noted for PCB capacitors.

---

* These estimates do not account for possible relocation of transformers, thus avoiding early replacement and reducing required inspection. In this sense, cost per pound of spill avoided may be overestimated.

Table 37. Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
10-Year Phase-Out	No Inspection	9.77	5,543	1,762
7-Year Phase-Out	No Inspection	11.34	6,262	1,811
6-Year Phase-Out	No Inspection	11.89	6,502	1,828
5-Year Phase-Out	No Inspection	12.44	6,741	1,846
3-Year Phase-Out	No Inspection	13.57	7,221	1,879
2-Year Phase-Out	No Inspection	14.16	7,460	1,898
Immediate Phase-Out	No Inspection	15.98	8,179	1,954
Indefinite Authorization with Retrofill	No Inspection	16.91	8,097	2,088

Reference Case: Indefinite authorization of askarel transformers posing an exposure risk to food or feed, with no mandatory inspection.

Parameters:
Equipment Life = 30 years new; 30 years rebuilt
Failure Rate = .2 percent per year
Percent of Failures that Spill = 47.7 percent
Leak Rate (w/o Failure) = .72 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 958 units in service, end of year 1979 (estimated as 10 percent of askarel transformers used in food or feed industries).

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 38. Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
Indefinite Authorization	Weekly Inspection	6.40	0	∞
10-Year Phase-Out	Weekly Inspection	12.41	5,543	2,238
7-Year Phase-Out	Weekly Inspection	13.37	6,262	2,136
6-Year Phase-Out	Weekly Inspection	13.71	6,502	2,108
5-Year Phase-Out	Weekly Inspection	14.05	6,741	2,084
3-Year Phase-Out[a]	Weekly Inspection	14.41	6,997	2,059
2-Year Phase-Out	Weekly Inspection	16.11	7,460	2,025
Immediate Phase-Out	Weekly Inspection	16.22	8,179	1,984

Reference Case: Indefinite authorization of askarel transformers posing an exposure risk to food or feed, with no mandatory inspection.

Parameters:
Equipment Life = 30 years new; 30 years rebuilt
Failure Rate = .2 percent per year
Percent of Failures that Spill = 47.7 percent
Leak Rate (w/o Failure) = .72 percent per year
Clean-up Cost per Spill = $6,000

Equipment Population: 958 units in service, end of year 1979 (estimated as 10 percent of askarel transformers used in food or feed industries).

[a] Phase-out begins in 1984 and ends in 1985.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 39. Sensitivity Analysis -- Equipment Life: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection

Alternative	Parameter	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided
5-Year Phase-Out	Life = 40	12.63	4,739	2,666
	Life = 60[a]	14.05	6,741	2,084
	Life = 80	17.35	10,486	1,655
2-Year Phase-Out	Life = 40	14.00	5,411	2,587
	Life = 60[a]	15.11	7,460	2,025
	Life = 80	18.24	11,241	1,622
Immediate Phase-Out	Life = 40	15.45	6,083	2,539
	Life = 60[a]	16.22	8,179	1,984
	Life = 80	19.17	11,996	1,598

[a] Base Case Assumption (includes 30-year life for new transformer plus 30 years for one rebuild).

Reference Case: Indefinite authorization of askarel transformers posing an exposure risk to food or feed, with no mandatory inspection.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 40. Sensitivity Analysis -- Transformer Price Escalation Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection

Alternative	Parameter	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided
5-Year Phase-Out	Transformer Price Escalation Rate = 9%[a]	14.05	6,741	2,084
	Transformer Price Escalation Rate = 12%	16.63	6,741	2,468
2-Year Phase-Out	Transformer Price Escalation Rate = 9%[a]	15.11	7,460	2,025
	Transformer Price Escalation Rate = 12%	16.49	7,460	2,203
Immediate Phase-Out	Transformer Price Escalation Rate = 9%[a]	16.22	8,179	1,984
	Transformer Price Escalation Rate = 12%	16.22	8,179	1,984

[a] Base Case Assumption.

Reference Case: Indefinite authorization of askarel transformers posing an exposure risk to food or feed, with no mandatory inspection.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 41. Sensitivity Analysis -- Clean-Up Cost Per Spill: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection

Alternative	Parameter	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided
5-Year Phase-Out	Clean-up Cost = $1250	14.09	6,741	2,090
	Clean-up Cost = $6000[a]	14.05	6,741	2,084
	Clean-up Cost = $30000	13.84	6,741	2,053
2-Year Phase-Out	Clean-up Cost = $1250	15.15	7,460	2,031
	Clean-up Cost = $6000[a]	15.11	7,460	2,025
	Clean-up Cost = $30000	14.87	7,460	1,993
Immediate Phase-Out	Clean-up Cost = $1250	16.28	8,179	1,990
	Clean-up Cost = $6000[a]	16.22	8,179	1,984
	Clean-up Cost = $30000	15.95	8,179	1,950

[a] Base Case Assumption.

Reference Case: Indefinite authorization of askarel transformers posing an exposure risk to food or feed, with no mandatory inspection.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 42. Sensitivity Analysis -- Discount Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection

Alternative	Parameter	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided
5-Year Phase-Out	Real Discount Rate = 1%	12.47	6,741	1,849
	Real Discount Rate = 3%[a]	14.05	6,741	2,084
	Real Discount Rate = 5%	15.18	6,741	2,252
2-Year Phase-Out	Real Discount Rate = 1%	13.03	7,460	1,747
	Real Discount Rate = 3%[a]	15.11	7,460	2,025
	Real Discount Rate = 5%	16.74	7,460	2,244
Immediate Phase-Out	Real Discount Rate = 1%	13.61	8,179	1,664
	Real Discount Rate = 3%[a]	16.22	8,179	1,984
	Real Discount Rate = 5%	18.44	8,179	2,255

[a] Base Case Assumption.

Reference Case: Indefinite authorization of askarel transformers posing an exposure risk to food or feed, with no mandatory inspection.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 43. Sensitivity Analysis -- Failure Rate: Cost-Effectiveness of Alternative PCB Use Authorizations for Askarel Transformers Posing an Exposure Risk to Food or Feed Subject to Mandatory Weekly Inspection

Alternative	Parameter	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided
5-Year Phase-Out	Failure Rate = .005	13.48	16,159	834
	Failure Rate = .002[a]	14.05	6,741	2,084
	Failure Rate = .0008	14.28	2,742	5,208
2-Year Phase-Out	Failure Rate = .005	14.52	17,934	809
	Failure Rate = .002[a]	15.11	7,460	2,025
	Failure Rate = .0008	15.35	3,031	5,064
Immediate Phase-Out	Failure Rate = .005	15.61	19,710	792
	Failure Rate = .002[a]	16.22	8,179	1,984
	Failure Rate = .0008	16.47	3,320	4,962

[a] Base Case Assumption.

Reference Case: Indefinite authorization of askarel transformers posing an exposure risk to food or feed, with no mandatory inspection.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

For phase-out periods of less than five years, raising the equipment and installation cost escalation rate by 3 percent increases costs by less than 20 percent. The effect declines with shorter phase-out periods, as explained for PCB capacitors.

Unlike the capacitor cases, variations in the clean-up cost per spill by a factor of 5 cause only 2 percent variations in cost-effectiveness. This much lower sensitivity obtains because unit capital costs are much larger for transformers and tend to dominate the results.

Varying the real discount rate by ±2 percent alters cost-effectiveness by up to 16 percent, for an immediate phase-out. However, varying the failure rate causes roughly inversely proportional changes in cost-effectiveness.

In summary, cost-effectiveness is most sensitive to the assumed failure rate; however, the sensitivities are in general smaller than for PCB capacitors. Similar tendencies can be assumed to hold for other askarel transformer categories as well.

MINERAL OIL TRANSFORMERS

Utility-Owned Mineral Oil Filled Transformers

Tables 44 and 45 present the cost-effectiveness of various phase-out policies for utility mineral oil transformers containing 50 ppm or greater concentrations of PCBs. The values range from more than $100 million per pound of avoided PCB release to about $9 million per pound avoided. These ratios are up to five orders-of-magnitude greater than for PCB capacitor or askarel transformer equipment groups -- a difference which clearly exceeds the uncertainty of the calculations. The high cost per pound results both from large testing costs and from low PCB concentrations, for which the estimates are probably accurate to within an order-of-magnitude.

Table 44. Cost-Effectiveness of Alternative PCB Use Authorizations for Utility-Owned Oil Filled Transformers Containing More than 50 ppm PCB

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
30-Year Phase-Out	No Inspection	3,736	37	100,964,380
20-Year Phase-Out	No Inspection	4,383	214	20,479,895
10-Year Phase-Out	No Inspection	6,159	581	10,599,950
Immediate Phase-Out	No Inspection	7,736	857	9,026,970

Reference Case: Indefinite authorization of utility-owned contaminated mineral oil transformers, with no mandatory inspection.

Parameters:
Equipment Life = 30 years new; 30 years rebuilt
Failure Rate = .2 percent per year
Percent of Failures that Spill = 47.7 percent
Leak Rate (w/o Failure) = .72 percent per year
Clean-up Cost per Spill = $250

Equipment Population: 2,386,077 units in service, end of year 1981.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

Table 45. Cost-Effectiveness of Alternative PCB Use Authorizations for Utility-Owned Oil Filled Transformers Containing More than 50 PPM PCB

Alternative	Conditions	Cost ($ Millions)	PCB Release Avoided (Pounds)	Cost-Effectiveness ($ Cost/Lb. Avoided)
Indefinite Authorization	Annual Inspection	2,657.4	0	∞
20-Year Phase-Out	Annual Inspection	6,574.0	214	30,719,061
Immediate Phase-Out	Annual Inspection	7,837.0	857	9,145,023

Reference Case: Indefinite authorization of utility-owned contaminated mineral transformers, with no mandatory inspection.

Parameters:
Equipment Life = 30 years new; 30 years rebuilt
Failure Rate = .2 percent per year
Percent of Failures that Spill = 47.7 percent
Leak Rate (w/o Failure) = .72 percent per year
Clean-up Cost per Spill = $250

Equipment Population: 2,386,077 units in service, end of year 1981.

SOURCE: Putnam, Hayes & Bartlett, Inc. using methodology described in Appendix A.

OTHER MINERAL OIL PCB-CONTAINING EQUIPMENT

While explicit evaluation of other mineral oil equipment was not performed, the cost-effectiveness of phase-out alternatives should be roughly comparable to utility-owned mineral oil transformers.

EEI (1982, p. 10) has estimated that circuit breakers, reclosers, and other utility electrical equipment have equivalent or lower levels of PCB contamination than mineral oil transformers. Comments to the 22 April 1982 Proposed Rule have further substantiated these findings for oil-filled cables. In view of this fact, testing costs will be extremely high on a "per contaminated unit identified" basis. This high testing cost will in turn result in extremely high marginal benefits per incremental pound of PCBs released, probably at least as high as for mineral oil transformers. Under these conditions, indefinite use authorization appears to be justified unless the cost to society (risk of injury to health or environment) is extremely high per pound of PCB release. In retrospect, this result is not surprising, since the equipment contains such a small proportion of PCBs, and since the cost of early phase-out is raised substantially by the need to test the equipment in order to identify those units contaminated at levels above 50 ppm. Notwithstanding such observations, the analysis of these equipment categories is qualitative only.

ASSESSMENT OF PCB DISPOSAL AND CAPACITOR MANUFACTURING CAPACITY REQUIRED TO ACCOMMODATE MANDATED PHASE-OUTS

CHAPTER 6

In order to determine whether EPA's electrical use rule is feasible, the adequacy of PCB disposal capacity and capacitor manufacturing capacity was assessed.* Since phase-out of askarel transformers posing an exposure risk to food or feed affects only a very small number of transformers, transformer manufacturing capacity was assumed to be adequate. This analysis concentrated on the period from 1982 to 1988 -- a period chosen to include the 3-year phase-out of askarel transformers posing an exposure risk to food or feed, and the 6-year phase-out of nonsubstation outdoor PCB capacitors and of PCB capacitors posing an exposure risk to food or feed. While manufacturing and disposal capacity will also be required in later years, the greatest capacity will be required during this earlier phase-out period.

---

* In principle, feasibility could also be limited by the availability of manpower to remove PCB capacitors and install replacements within the prescribed phase-out period. For example, using the EEI (1982, p. 148) estimate of 4 man-hours per PCB capacitor yields an average requirement of less than three-quarters of a man-year (2000 hours/year) per electric utility for complete nonsubstation capacitor removal and replacement. Hence, it is very unlikely that the skilled-labor component of this requirement could not be met over a 6-year period. Accordingly, labor requirements were not further assessed.

PCB DISPOSAL CAPACITY

Current disposal rules require that PCB fluids be destroyed by high-temperature incineration. Such disposal will be required for all of the PCBs in large PCB power capacitors and askarel transformers, and for mineral oil equipment in which the fluid is contaminated to levels greater than 500 ppm with PCB. As noted in Chapter 1, large PCB power capacitors and askarel transformers contain over 99 percent of the PCBs used in utility electrical equipment, and the majority of PCBs used in all electrical equipment. Accordingly, an analysis was performed for seven equipment categories that comprise all large PCB power capacitors and askarel transformers.* Since mineral oil equipment can be assumed to be PCB-contaminated or non-PCB by this rulemaking, it is assumed that contaminated mineral oil will be disposed in utility high temperature boilers. The EEI survey of the 100 largest utilities indicates that utilities currently plan to provide in excess of 9,240 gallons per hour of such capacity. This capacity could accommodate the fluid in all utility-owned mineral oil filled equipment in an 18-year period.

Using the methodology described in Appendix A, the annual weight of PCBs disposed from large PCB power capacitors and askarel transformers was estimated for the 1982 to 1988 period. Table 46 lists the disposal requirements for each of seven equipment groups, along with the total weight of PCBs disposed. The required annual capacity ranges from 16.0 million pounds in 1983 to about 16.8 million pounds in 1988.

---

* PCB capacitors used for high-intensity discharge applications, in small appliances, and for fluorescent lighting ballast were estimated to contain 180 million pounds of PCBs in 1976 (Versar, 1977, pp. 1-5, 1-6). If 150 million pounds of these PCBs still remain in use and are disposed in incinerators over the next 15 years, additional disposal capacity of 10 million pounds per year could be required. However, the wide distribution of these equipment and alternative disposal in chemical waste landfills makes it unlikely that this incineration capacity will actually be required.

Table 46. Required PCB Disposal Over the 5-Year Period, 1983-1987

	PCBs Disposed From Capacitors (Pounds)				PCBs Disposed From Askarel Transformers (Pounds)			
Year	Food/Feed[a]	Utility Distribution[b]	Utility Substation[c]	Non-Utility[d]	Food/Feed[e]	Utility[f]	Non-Utility[g]	Total (Pounds)
1982	2,224	902,907	1,029,927	247,349	41,923	1,524,812	4,172,157	7,921,299
1983	2,342	940,946	1,084,497	259,511	44,454	1,616,887	4,415,592	8,364,229
1984	20,305	7,350,175	1,138,702	271,566	982,306	1,711,509	4,665,684	16,140,247
1985	20,305	7,350,175	1,192,102	283,413	982,306	1,808,343	4,921,514	16,558,156
1986	20,305	7,350,175	1,244,222	294,943	--	1,906,884	5,181,708	15,998,235
1987	20,305	7,350,175	1,294,548	306,038	--	2,006,414	5,444,329	16,421,809
1988	20,305	7,350,175	1,342,545	316,576	--	2,105,989	5,706,832	16,842,422

[a] Current rule requires phase-out by 1988.
[b] Current rule requires phase-out by 1988.
[c] Current rule authorizes use indefinitely.
[d] Current rule authorizes use indefinitely.
[e] Current rule requires phase-out by 1985.
[f] Current rule authorizes use indefinitely.
[g] Current rule authorizes use indefinitely.

SOURCE: Putnam, Hayes & Bartlett, Inc.

EPA currently estimates that a licensed incineration capacity of 5,000 pounds of PCBs per hour will be available (at the Rollens and ENSCO facilities). At an 80 percent capacity factor, such capacity would provide for incineration of about 35 million pounds annually -- over double the required capacity. Conversely, if this capacity were available only 38 percent of the time, it would still be sufficient to meet the peak disposal requirement of 16.8 million pounds in 1988. At 61 percent availability, a 5,000 pounds per hour disposal capacity could accommodate both the 16.8 million pounds peak load of PCBs from large power capacitors and askarel transformers, and up to 10 million pounds of PCBs annually from small PCB capacitors.

CAPACITOR MANUFACTURING CAPACITY

Phase-out of PCB capacitors posing an exposure risk to food or feed and of utility distribution PCB capacitors will require replacement of about 1.24 million capacitors. These PCB capacitors, estimated by EEI (1982) to average 100 KVAR per unit, will be replaced on about a 1-for-2 basis with 200 KVAR non-PCB units. The total number of PCB capacitors replaced due to early phase-out, failure, or obsolescence between 1982 and 1988 was estimated by PHB using the methodology and parameters described in Appendix A; the results are tabulated in Table 47. Assuming that all PCB capacitors average 100 KVAR per unit, a peak manufacturing annual capacity of about 29.1 million KVAR (145,500 200-KVAR units) is required for replacement of PCB capacitors.

The reported domestic production of high voltage power capacitors in 1981 was about 29 million KVAR.* In a survey of domestic capacitor manufacturers by NEMA, the four respondents all indicated that production could be increased 65 percent by 1983 or earlier. Such an increase would result in an annual production of 47.85 million KVAR, which, if solely devoted to PCB capacitor replacement, would be more than sufficient to meet peak replacement demands.

---

* This figure is from NEMA Product Statistical Bulletin for the Capacitor Section (8-CP) for 1981. The figure does not include sales which, if reported, would reveal individual company data. Also produced in 1981 were 1,455,231 KVAR of low voltage power capacitors.

Table 47. Large PCB Power Capacitors Retired Between 1982 and 1987

Year	PCB Capacitors Posing Risk to Food or Feed[a]	Utility Distribution Capacitors[b]	Utility Substation Capacitors[c]	Non-Utility Capacitors[d]	Total Units Retired
1982	96	28,828	32,884	10,662	72,470
1983	101	30,043	34,626	11,186	75,965
1984	875	234,680	36,357	11,705	283,617
1985	875	234,680	38,062	12,216	285,833
1986	875	234,680	39,726	12,713	287,994
1987	875	234,680	41,333	13,191	290,079
1988	875	234,680	42,865	13,646	291,191

[a] Current rule requires phase-out by 1988.
[b] Current rule requires phase-out by 1988.
[c] Current rule authorizes use indefinitely.
[d] Current rule authorizes use indefinitely.

NOTE: Accelerated phase-outs are assumed to occur uniformly over the phase-out period for each group.

SOURCE: Putnam, Hayes & Bartlett, Inc.

While purchase of capacitors can usually be deferred (at the expense of maintaining a lower power factor and hence less efficient power usage), it is unlikely that such deferral would occur voluntarily unless capacitor prices were to rise. Independent estimates of the current capacitor demand for new applications range from 9.7 million KVAR to 20.3 million KVAR per year, and can be alternatively derived as follows:

1. From utility survey data:
    a. In 1980, 112,000 PCB capacitors were retired (EEI, 1982, p. 142).
    b. In 1980, 20.9 million KVAR of high voltage power capacitors were produced (NEMA statistical report, 1980).
    c. Hence, at 100 KVAR per PCB capacitor:

        20.9 million - 112,000 (100) = 9.7 million KVAR

        all assumed to be for new applications.
2. From NEMA Survey of Manufacturers:
    a. A survey respondent noted that the average shipments over the 1966 to 1981 period were 17.3 million KVAR per year, assumed to be the normal requirement.
    b. Assume normal annual requirements are all for new applications.
3. From discussions with a major utility:
    a. A major utility estimates that 60 percent to 70 percent of its capacitors are purchased for new applications.*
    b. Production in 1981 was 29 million KVAR (NEMA statistical report, 1981).

---

* Interview with officials from the New England Electric System, 13 May 1982.

c. 70 percent of 29 million = 20.3 million KVAR per year, assumed to be for new applications.

If annual requirements for new applications are in fact as much as 20.3 million KVAR, 27.55 million KVAR per year (47.85 - 20.3) could be produced for PCB capacitor replacement. In order to meet a peak annual requirement of 29.1 million KVAR for PCB capacitor replacement, the purchase of 1.55 million KVAR for new applications (about 7,750 units) would have to be deferred until 1989 or later. Conversely, expanded production could serve a demand of 18.75 million KVAR per year for new applications while still meeting the peak requirement of 29.1 million KVAR for PCB capacitor replacement.

SUMMARY

A mandated 3-year phase-out of askarel transformers posing an exposure risk to food or feed, and a 6-year phase-out of PCB nonsubstation outdoor capacitors and PCB capacitors posing an exposure risk to food or feed will require a peak annual PCB disposal capacity of 16.8 million pounds and a peak annual power capacitor manufacturing capacity of 29.1 million KVAR (about 145,500 200-KVAR units). These estimates include manufacturing and/or disposal requirements associated with PCB capacitors and askarel transformers in other equipment categories for which EPA is authorizing indefinite use.

EPA's estimated existing or planned disposal capacity of 5,000 pounds of PCBs per hour should be sufficient to meet peak disposal requirements even under very conservative conditions. However, an estimated capacitor manufacturing capacity of 47.85 million KVAR (165 percent of 1981 production) will require that purchase of capacitors for new applications be deferred, if the total demand for new applications exceeds 18.75 million KVAR per year. While two of three independent estimates of this demand fall below 18.75 million KVAR, it is possible that purchase of up to 1.55 million KVAR of capacitors for new applications (or for replacement of PCB units) will be deferred up to five years as a result of PCB capacitor phase-out.

DISTRIBUTIONAL EFFECTS CHAPTER 7

The previous chapters have discussed benefits, costs and cost-effectiveness from society's perspective, but they do not address the issue of who bears these costs. More specifically, the question of whether any particular sector of the economy will be unreasonably burdened has not been addressed.

The following distributional analysis describes the impact of the nonsubstation outdoor PCB capacitor phase-out and of the phase-outs of PCB transformers and capacitors posing an exposure risk to food or feed on the particular sectors of the economy they most affect: the electric utility industry and its customers in the former case and the food and feed industry in the latter case.

The distributional impacts associated with the phase-out of nonsubstation outdoor capacitors and food and feed capacitors and transformers are not large. The net present value of the nonsubstation capacitor phase-out costs is only 0.05 percent of 1979 net investment in electric plant nationally, and the maximum annual increase in required investment as a consequence of the phase-out is only 0.34 percent of the 1978 to 1979 growth in net electric plant investment. From the customers' perspective, the maximum annual increase in required revenues is only 0.1 percent of 1979 national electric operating revenues.

For askarel transformers and PCB capacitors posing an exposure risk to food or feed, the before-tax net present value of phase-out costs is less than 0.1 percent of 1976 assets in the food and feed industry. The total increase in cash flow requirements (before-tax) from 1984 to 1988 attributable to the phase-out is less than 0.2 percent of the estimated 1979 internal cash flow of the food and feed industry.

Some of these food and feed transformers and capacitors may be owned by the utility industry. Even if all of these transformers and capacitors are owned by the electric utility industry, the total impact on the utility industry would be very small, less than 10 percent of the impacts estimated for the phase-out of nonsubstation outdoor PCB capacitors alone.

The impacts associated with each of the two phase-out programs, nonsubstation outdoor PCB capacitors and PCB transformers and capacitors posing an exposure risk to food or feed, are described in detail in the following sections.

NONSUBSTATION OUTDOOR PCB CAPACITORS

The five-year authorization of nonsubstation outdoor PCB capacitors will accelerate replacement and disposal of this equipment. The costs associated with this acceleration will be borne by the nation's electric utilities and their customers. To assess the magnitude of the impact, three types of analyses were undertaken.

The first of these compares the net present value of the phase-out costs with net investment in electric plant. In an unregulated industry this comparison illustrates the upper bound of industry or stockholder impacts, assuming none of the added costs can be passed on to customers. In a regulated industry such as the electric utility industry, where costs can, in principle, be passed on to customers, and where 25 percent of the affected equipment is estimated to be owned by public, rather than investor-owned utilities, this comparison is somewhat less informative. However, it does provide some sense of the scale of the impacts relative to investment in the industry.

The second analysis assesses the cash flow and financing implications of the phase-out. While the net present value of costs is the best measure of the cost of the regulation, these costs are not evenly distributed through time. During the phase-out period (1984 through 1988), out-of-pocket costs increase substantially over the level that would have obtained in the absence of the phase-out. After the phase-out is completed, annual out-of-pocket costs are lower than they otherwise would have been. An analysis of incremental out-of-pocket costs incurred during the 1984 to 1988 period was undertaken to determine whether these additional costs might result in financing or liquidity problems. The annual incremental costs were calculated and compared both to 1979 electric plant investment and to the 1978-1979 growth in electric plant investment.

The third analysis determines the customer impacts of the regulation, the extent to which electricity prices would rise as a result of the additional costs incurred. Here again, the effects are not evenly distributed through time. The maximum price impact would be expected during the phase-out period when out-of-pocket cost increases were at their peak. Accordingly, the price analysis focused on the phase-out period, 1984 to 1988. In each year, the revenue increase that would result under utility ratemaking practices was calculated and compared to 1979 total revenues.

For each of these three analyses, it was desirable to divide the utility industry into several segments to reflect the financial, regulatory, ownership, and size differences within the industry. The extent to which this could be accomplished was determined by the availability of internally consistent data. However, sufficient financial and operating data were available to divide the utility industry into four groups:*

- Private, investor-owned utilities;
- Local public utilities;
- Rural Electrification Administration (REA) borrowers (Rural Electric Cooperatives); and
- Federally-owned utilities.

---

* The data source for all customer, asset, and revenue information is the 1981 Public Power Directory.

Each of the three above-described analyses were conducted for the industry as a whole and for each of these four groups. However, to accomplish this, the total estimated inventory of nonsubstation outdoor PCB capacitors had to be allocated to these four groups. The allocation procedure and the results of the three different types of analyses are summarized below.

Allocation Procedure

The only comprehensive source of information regarding nonsubstation PCB capacitor ownership is the EEI/USWAG database. However, this database contains information from only the 100 largest utilities, and hence is not exhaustive. While the investor-owned and federally-owned groups are well represented in the sample, neither local public utilities nor REA borrowers were extensively sampled. As a result, it was necessary to link distribution capacitor ownership to some other characteristic, such as revenue, sales, or customers, and to use that relationship to allocate capacitors among the groups. A series of simple regression analyses were undertaken by EEI's contractor at PHB's request. These analyses demonstrated that number of customers was the best single predictor of nonsubstation PCB capacitor ownership and an equation linking capacitors to number of customers was developed. Using number of customer data for each of the four groups, capacitor ownership was allocated. The results are shown in Table 48. Private investor-owned utilities account for 76 percent of the total, local public 14 percent, REA borrowers 10 percent, and federally-owned essentially 0 percent.

These allocations are, of course, uncertain. The underlying database is heavily skewed toward investor- and federally-owned utilities, and the predictive equation does not explain all the variance. However, these allocations are based on the best available data. The effect of this uncertainty will be addressed as each of the three types of analyses is discussed.

Table 48. Allocation of Pole-Top Distribution Capacitors

	Number of Customers	Number of Capacitors	Percent of Total
Private	69,117,546	912,450	75.82
Local Public	12,413,025	165,353	13.74
REA Borrowers	9,275,086	123,834	10.29
Federal	12,911	1,806	0.15
		1,203,443	100.00

SOURCE: Putnam, Hayes & Bartlett, Inc.

Comparison of Phase-Out Costs to Net Investment in Electric Plant

As discussed in Chapter 4, the before-tax net present value of the costs associated with a 5-year nonsubstation outdoor PCB capacitor phase-out is estimated to be $135.9 million.* Using the proportion of capacitors estimated to be owned by each group, this cost can also be allocated and compared with net investment in electric plant. Table 49 summarizes the cost, net investment in electric plant, and the ratio of cost to net investment for each of the four groups and for the total.

As the table shows, even on a before-tax basis, costs are a very small proportion of investment, 0.053 percent overall, with a range of 0.001 percent for federally-owned to 0.072 percent for REA borrowers.** In no case is the impact severe, and it does not appear that any uncertainty in ownership allocation would affect this conclusion.

Comparison of Phase-Out Cash Cost to Growth in Net Investment

While the total cost of the capacitor phase-out is estimated to be $135.9 million, cash costs during the 1984 to 1988 phase-cut period will be somewhat higher, to be offset by lower cash costs in later periods. The cash costs themselves are of two types: costs related to the purchase and installation of new equipment which must be capitalized and thus financed; and costs which are expensed at the time they are incurred. Theoretically at least, these latter costs are recovered through rates on a current basis and need not be financed. Thus the

---

* This is a conservative estimate as it ignores the benefits of replacing less efficient capacitors sooner. As discussed in Chapter 3, these benefits may be substantial, reducing the net cost of the phase-out to $30 million or lower.

** The comparison of 1982 dollars and 1979 dollars is conservative, tending to overstate impacts.

Table 49. Comparison of Phase-Out Costs to Net Investment in Electric Plant

	Phase-Out Costs[a] ($ million)	1979 Net Investment ($ million)	Cost as a Percent of Investment
Investor-Owned	103.039	188,897.507	.055
Local Public	18.673	30,645.534	.061
REA Borrowers	13.984	19,521.479	.072
Federally-Owned	0.204	18,710.400	.001
Total	135.900	257,774.920	.053

[a] Before-tax in 1982 dollars.

SOURCE: Putnam, Hayes & Bartlett, Inc.

financing and liquidity analysis focused on the former type of costs.*

Table 50 summarizes the incremental cash costs incurred in each year of the phase-out. As expected, the $496.5 million total for the 1984 to 1988 period is substantially greater than the $135.9 million net cost of the phase-out. The table also shows that the capitalized portion of the incremental costs accounts for a large portion, 86 percent, of the total incremental costs.

Table 51 shows how this total increase in capitalized costs is distributed among the four different utility segments and how it compares with 1979 net investment in electric plant.** The average total increase in investment attributable to the phase-out is 0.17 percent of 1979 net investment, with REA borrowers having the largest increase, 0.22 percent of 1979 net investment.

Another way to view this issue is to compare the maximum annual increase in capitalized costs with the annual growth in utility investment. Table 52 summarizes these calculations. As the table shows, the maximum annual increase in capitalized cost is extremely small relative to the growth in electrical investment, averaging only 0.34 percent.** The actual proportion is even smaller than shown, as the growth in net investment data used do not reflect the reinvestment of depreciation cash flow. Except for federally-owned utilities, for which the proportion is even lower, the remaining three groups are fairly tightly clustered around the average figure.

It does not appear that the nonsubstation outdoor PCB capacitor phase-out will impose large financing burdens in aggregate or for any particular subset of the utility

---

* In the absence of adequate ratemaking, costs which are expensed but not recovered through rates contribute to financing requirements, although on an after-tax basis. However, as the capitalized portion of cash costs attributable to the phase-out is 86 percent of the total, the results and conclusions would not be materially different even if the entire cash cost had to be financed.

** Comparisons of 1982 dollars and 1979 dollars are conservative, tending to overstate impacts.

Table 50. Incremental Cash Costs Associated With Distribution Capacitor Phase-Out (Millions of 1982 Dollars)

Year	Capitalized ($ million)	Expensed ($ million)	Total ($ million)
1984	86.3	18.9	105.2
1985	85.8	16.4	102.2
1986	85.3	14.0	99.3
1987	84.8	11.5	96.3
1988	84.4	9.1	93.5
Total	426.6	69.9	496.5

SOURCE: Putnam, Hayes & Bartlett, Inc.

Table 51. Total Increase in Capitalized Costs as a Percentage of Net Investment

	Total Increase in Capitalized Costs (Millions of 1982 Dollars)	1979 Net Investment ($ million)	Increase in Capitalized Costs as a Percent of Net Investment
Investor-Owned	323.5	188,897.5	0.17
Local Public	58.6	30,645.5	0.19
REA Borrowers	43.9	19,521.5	0.22
Federally-Owned	0.6	18,710.4	0.003
Total	426.6	257,774.9	0.17

SOURCE: Putnam, Hayes & Bartlettt, Inc.

Table 52. Total Increase in Capitalized Costs as a Percentage of Growth in Electric Plant Investment

	Maximum Annual Increase in Capitalized Costs ($ million)	1978-1979 Growth in Net Electric Plant Investment[a] ($ million)	Maximum Increase as a Percent of 1978-1979 Net Investment Growth
Investor-Owned	65.4	18,508.2	0.35
Local Public	11.9	3,621.3	0.33
REA Borrowers	8.9	2,903.7	0.31
Federally-Owned	0.1	149.0	0.07
Total	86.3	25,182.2	0.34

[a] Does not include reinvestment of depreciation cash flow.

SOURCE: Putnam, Hayes & Bartlett, Inc.

industry. Again, the uncertainty underlying the ownership allocation could not be of sufficient magnitude to alter this conclusion.

Comparison of Revenue Requirement Increases With 1979 Revenue Requirements

In a regulated industry such as the utility industry, cost increases translate into price increases in a fairly predictable manner.* Costs which are expenses are theoretically recovered through electric rates on a current basis. Capitalized costs are typically recovered through rates over the useful life of the asset, although the magnitude and timing of the recovery varies depending on the type of utility, its financing opportunities, and regulatory policies.

Table 53 summarizes the revenue increases attributable to the phase-out for the years 1984 through 1989, as well as their percentage of 1979 actual electric operating revenues.** As the table shows, the maximum revenue increase that results from the phase-out is 0.10 percent of 1979 revenues, and the average is substantially lower. As expected, the revenue impacts peak in the last year of the phase-out period (1988), and decline substantially in the following year. Local public and investor-owned utilities are most affected. In the former case, this is attributable to a lower average cost of electricity, and hence proportionally fewer revenues, while in the latter case it is due to an inability to issue tax-exempt debt instruments and the fact that income taxes must be recovered through rates. For REA borrowers, the higher intensity of capacitor investment is more than compensated for by financing and tax advantages.

This revenue impact is not large in aggregate, and no particular type of utility is particularly affected.

---

* Here "perfect" or theoretical ratemaking is assumed so that the maximum possible revenue effect can be assessed. Less than perfect ratemaking would result in smaller revenue increases.

** This comparison of 1982 dollars and 1979 dollars is conservative, and will tend to overstate the effect on customers.

Table 53. Maximum Revenue Impact of Distribution Capacitor Phase-Out

	1984		1985		1986		1987		1988		1989	
Investor-Owned												
Annual Revenue Requirement Increase (Millions of 1982 $)	34.7		49.4		61.0		69.8		76.5		56.6	
Percent of 1979 Revenue		0.048		0.068		0.084		0.096		0.105		0.078
Local Public												
Annual Revenue Requirement Increase (Millions of 1982 $)	5.7		7.7		9.2		10.2		10.9		7.4	
Percent of 1979 Revenue		0.057		0.077		0.092		0.103		0.110		0.074
REA Borrowers												
Annual Revenue Requirement Increase (Millions of 1982 $)	3.7		4.9		5.7		6.4		6.8		4.7	
Percent of 1979 Revenue		0.046		0.061		0.071		0.079		0.084		0.058
Federally-Owned												
Annual Revenue Requirement Increase (Millions of 1982 $)	0.1		0.1		0.1		0.1		0.1		0.1	
Percent of 1979 Revenue		0.003		0.003		0.003		0.003		0.003		0.003
Total	44.2	0.047	62.1	0.066	76.0	0.081	86.5	0.092	94.3	0.100	68.8	0.073

SOURCE: Putnam, Hayes & Bartlett, Inc.

Again, this conclusion seems quite robust with respect to any uncertainty in the underlying data.

CAPACITORS AND ASKAREL TRANSFORMERS POSING AN EXPOSURE RISK TO FOOD AND FEED

The 3-year authorization of askarel transformers posing an exposure risk to food or feed and the 6-year authorization of capacitors posing an exposure risk to food or feed will accelerate replacement and disposal of this equipment. The costs associated with this acceleration will be borne by the food and feed industry and/or its customers. To the extent that PCB equipment used in the food and feed industry is owned by electric utilities, the utilities and their customers will also be affected.

Two types of analyses were conducted to determine the impacts on the food and feed industry. First, the before-tax net costs of the phase-out were compared to total assets in the food and feed industry. Even though before-tax phase-out costs were used, this comparison yields an upper-bound estimate of the impact on the industry if none of the added costs are passed on to consumers through higher prices.

The second type of analysis is a liquidity or cash flow analysis. As for nonsubstation capacitors, the incremental cash costs during the phase-out (1984 through 1988) will substantially exceed the net cost of the phase-out over the next 40 or 50 years. Thus the total incremental cash costs in 1984 through 1988 were calculated and compared to an estimate of internal cash flow in the food and feed industry. The comparison of five years' cash cost to a single year's cash flow is an extremely conservative assessment of cash flow impacts.

Potential consumer impacts resulting from price increases were not assessed due to the extremely low level of cash impacts. The effects on utilities and their customers that would result from utility ownership of this equipment were assessed in comparison to the impact associated with the nonsubstation outdoor PCB capacitor phase-out.

As in the case of the distributional analysis of the capacitor phase-out, it is useful to divide the food and feed industry into a number of segments. The four-digit SIC code level was chosen for analysis. However, the total number of capacitors and transformers estimated to pose an exposure risk to food or feed had to be allocated to these groups. The procedure for allocating these units and the results of the two types of analyses conducted are summarized in the following sections of this chapter.

Allocation Procedure

The allocation of capacitors and transformers to the four-digit SIC code level drew heavily on an earlier PHB analysis of this equipment.* In that study, the entire population of PCB capacitors and askarel transformers in use in the food and feed industry was estimated at the four-digit SIC code level. EPA's estimate that 10 percent of the equipment in use poses an exposure risk was applied evenly to the equipment inventory in each SIC code. Table 54 summarizes the SIC codes considered and the proportion of the equipment posing an exposure risk for each SIC code. As the table shows, the equipment is well distributed among the 50 food and feed categories. The maximum proportion of equipment in any single SIC code is 9.5 percent for transformers and 11.7 percent for capacitors, both in SIC code 2011, meat packing.

Comparison of Net Phase-Out Costs With Food and Feed Industry Assets

As discussed in Chapter 4, the net present value of the two-year equipment phase-out is estimated to be $15.7 million, $14.4 million for transformers and $1.3 million for capacitors. These costs can be allocated to SIC codes as shown in Table 55, using the earlier discussed equipment distribution proportions. As the table shows, the costs for most SIC codes are quite small. Only two SIC codes -- meat packing and nitrogenous fertilizers -- will incur costs in excess of $1 million.

---

* Putnam, Hayes & Bartlett, Inc., The Impact of Additional Regulation of Polychlorinated Biphenyls (PCBs) in Food-Related Industries, 8 December 1980.

Table 54. Distribution of Equipment Posing an Exposure Risk to Food or Feed

SIC	Industry	Percentage of Transformers	Percentage of Capacitors
2011	Meat Packing	9.5	11.7
2013	Prepared Meat	4.2	3.8
2016	Poultry	4.6	5.8
2017	Eggs	0.6	0.4
201	MEAT	18.9	21.7
2021	Butter	0.8	0.5
2022	Cheese	1.6	1.2
2023	Condensed Milk	1.6	1.0
2024	Ice Cream	5.3	4.4
2026	Milk	6.3	6.6
202	DAIRY	15.6	13.7
2032	Canned Specialties	1.1	1.2
2033	Canned F&V	3.3	3.1
2034	Dehydrated F&V	1.2	0.9
2035	Pickles	1.1	0.8
2037	Frozen F&V	3.8	3.6
2038	Frozen Specialties	2.7	2.4
203	PRESERVED F&V	13.2	12.0
2041	Flour	2.0	2.8
2043	Cereal	0.5	0.9
2044	Rice	0.8	0.5
2045	Prepared Flour	0.3	0.3
2046	Corn	3.2	3.3
2047	Pet Food	0.7	1.2
2048	Feeds	2.3	1.8
204	GRAIN	9.8	10.8
2051	Bread	1.6	2.4
2052	Cookies	0.8	0.9
205	BAKERY	2.4	3.3

Table 54. Distribution of Equipment Posing an Exposure Risk to Food and Feed (Continued)

SIC	Industry	Percentage of Transformers	Percentage of Capacitors
2061	Raw Cane	0.5	0.4
2062	Refining	1.7	1.1
2063	Beet	1.6	1.2
2065	Confections	2.2	2.2
2066	Chocolate	0.6	0.6
2067	Gum	0.2	0.2
206	SUGAR	6.8	5.7
2074	Cottonseed	0.8	0.7
2075	Soybean	2.9	2.6
2076	Vegetable	0.2	0.1
2077	Animal	--	--
2079	Shortening	0.9	0.9
207	FATS AND OILS	4.8	4.3
2082	Malt Beverages	2.5	3.5
2083	Malt	0.6	0.6
2084	Wines	0.7	0.6
2085	Distilled Liquors	1.4	1.3
2086	Soft Drinks	3.1	2.5
2087	Flavorings	0.6	0.5
208	BEVERAGES	8.9	9.0
2091	Canned Fish	0.3	0.3
2092	Frozen Fish	1.1	1.0
2095	Coffee	0.7	0.8
2098	Macaroni	0.5	0.5
2099	Other	2.9	3.1
209	MISCELLANEOUS	5.5	5.7
20	FOOD - TOTAL	85.9	86.2
2873	Fertilizers, Nitrogenous	7.5	7.3
2874	Fertilizers, Phosphatic	4.5	4.8
2875	Fertilizer Mixing	0.1	0.1
2879	Pesticides & Other	2.0	1.6
287	AGRICULTURAL CHEMICALS - TOTAL	14.1	13.8
TOTAL		100.0	100.0

SOURCE: Putnam, Hayes & Bartlett, Inc.

Table 55. Food and Feed Phase-Out Costs By Equipment Type and as a Percentage of Assets

SIC	Industry	Phase-Out Costs (Millions of 1982 Dollars)			Phase-Out Costs as a Percentage of 1976 Assets[a]
		Transformers	Capacitors	Total	
2011	Meat Packing	1.368	.157	1.525	.080
2013	Prepared Meat	.605	.052	.657	.093
2016	Poultry	.662	.078	.740	.127
2017	Eggs	.086	.006	.092	.092
201	MEAT	2.722	.292	3.014	
2021	Butter	.115	.006	.121	.166
2022	Cheese	.230	.016	.246	.062
2023	Condensed Milk	.230	.014	.244	.075
2024	Ice Cream	.763	.060	.823	.216
2026	Milk	.907	.090	.997	.061
202	DAIRY	2.246	.185	2.431	
2032	Canned Specialties	.158	.016	.174	.058
2033	Canned F&V	.475	.042	.517	.041
2034	Dehydrated F&V	.173	.012	.185	.059
2035	Pickles	.158	.010	.168	.060
2037	Frozen F&V	.547	.048	.595	.080
2038	Frozen Specialties	.389	.032	.421	.062
203	PRESERVED F&V	1.901	.161	2.062	
2041	Flour	.288	.038	.326	.054
2043	Cereal	.072	.012	.084	.018
2044	Rice	.115	.006	.121	.074
2045	Prepared Flour	.043	.004	.047	.029
2046	Corn	.461	.044	.505	.041
2047	Pet Food	.101	.016	.117	.018
2048	Feeds	.331	.024	.355	.069
204	GRAIN	1.411	.145	1.556	
2051	Bread	.230	.032	.262	.019
2052	Cookies	.115	.012	.127	.027
205	BAKERY	.346	.044	.390	

[a] Putnam. Hayes & Bartlett, Inc., 1980, p. 64.

Table 55. Food and Feed Phase-Out Costs By Equipment Type and as a Percentage of Assets (Continued)

SIC	Industry	Phase-Out Costs (Millions of 1982 Dollars)			Phase-Out Costs as a Percentage of 1976 Assets[a]
		Transformers	Capacitors	Total	
2061	Raw Cane	.072	.006	.078	.014
2062	Refining	.245	.014	.259	.048
2063	Beet	.230	.016	.246	.037
2065	Confections	.317	.030	.347	.047
2066	Chocolate	.086	.008	.094	.033
2067	Gum	.029	.002	.031	.023
206	SUGAR	.979	.078	1.057	
2074	Cottonseed	.115	.010	.125	.072
2075	Soybean	.418	.036	.454	.055
2076	Vegetable	.029	.002	.031	.062
2077	Animal	--	--	--	--
2079	Shortening	.130	.012	.142	.027
207	FATS AND OILS	.691	.058	.749	
2082	Malt Beverages	.360	.048	.408	.013
2083	Malt	.086	.008	.094	.065
2084	Wines	.101	.008	.109	.025
2085	Distilled Liquors	.202	.018	.220	.042
2086	Soft Drinks	.446	.034	.480	.039
2087	Flavorings	.086	.006	.092	.042
208	BEVERAGES	1.282	.121	1.403	
2091	Canned Fish	.043	.004	.047	.027
2092	Frozen Fish	.158	.014	.172	.119
2095	Coffee	.101	.010	.111	.020
2098	Macaroni	.072	.006	.078	.058
2099	Other	.418	.042	.460	.054
209	MISCELLANEOUS	.792	.078	.870	
20	FOOD - TOTAL	12.370	1.162	13.532	
2873	Fertilizers, Nitrogenous	1.080	.097	1.177	.049
2874	Fertilizers, Phosphatic	.648	.064	.712	.041
2875	Fertilizer Mixing	.014	.002	.016	.021
2879	Pesticides & Other	.288	.022	.310	.035
287	AGRICULTURAL CHEMICALS - TOTAL	2.030	.185	2.215	
TOTAL		14.400	1.347	15.747	

SOURCE: Putnam, Hayes & Bartlett, Inc.

These costs can also be expressed as a percentage of assets (1976 assets*), as shown in the last column of Table 55. These figures demonstrate that the impact, even measured on a before-tax basis, is small.** The largest impact on a proportional basis is 0.216 percent for the ice cream SIC. For most of the categories, the phase-out costs are less than 0.1 percent of assets.

The other interesting point illustrated by this column of Table 55 is that the absolute costs in dollars are not strongly correlated with the proportion of costs to assets. For meat packing the $1.525 million cost which is the highest on an absolute basis translates into 0.080 percent of assets, well below the 0.216 percent maximum for SIC code 2024.

Comparison of 1984-1988 Phase-Out Cash Costs With Internal Cash Flow

The cash flow effects of the phase-out will be most pronounced from 1984 to 1988 when out-of-pocket replacement and disposal costs are incurred. Table 56 summarizes the 1984 through 1988 before-tax costs associated with the phase-out. The $31.6 million total is approximately twice the $15.7 million net cost of the phase-out. Of the $31.6 million, $29.0 million, or 92 percent, result from the askarel transformer phase-out.

Table 57 summarizes the allocation of these 1984-1988 pre-tax cash costs across SIC codes. Again the impacts seem quite small. Two categories have costs between $2.0 and $3.1 million, and 8 categories have costs between $1 and $2 million. The remaining 39 categories all have costs of less than $1 million.

---

* See PHB, 1980, pp. 64, 65. Again, the comparison of 1982 dollars and 1976 dollars is conservative, tending to overstate impacts.

** EPA estimates that a small number of askarel electromagnets are in service which pose an exposure risk to food or feed. The costs associated with replacing or moving this equipment is believed to be extremely small, even relative to the phase-out costs attributable to food and feed askarel transformers.

Table 56. 1983-1984 Phase-Out Cash Costs[a]

	Transformers ($ million)	Capacitors ($ million)	Total ($ million)
1983	14.6	1.4	16.0
1984	14.3	1.4	15.7
Total	28.9	2.8	31.7

---

[a] Before-tax.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Table 57. 1984-1988 Food and Feed Phase-Out Costs as a Percentage of 1979 Estimated Cash Flow

		1984-1988 Phase-Out Cash Costs[a] (Millions of 1982 Dollars)			1983-1984 Cash Costs as a Percent of 1979 Estimated Internal Cash Flow
SIC	Industry	Transformers	Capacitors	Total	
2011	Meat Packing	2.753	.301	3.055	.148
2013	Prepared Meat	1.217	.098	1.314	.106
2016	Poultry	1.333	.149	1.482	.180
2017	Eggs	.174	.010	.185	.210
201	MEAT	5.476	.559	6.035	
2021	Butter	.232	.013	.245	.589
2022	Cheese	.464	.031	.495	.067
2023	Condensed Milk	.464	.026	.490	.058
2024	Ice Cream	1.535	.113	1.649	.358
2026	Milk	1.825	.170	1.995	.100
202	DAIRY	4.521	.353	4.873	
2032	Canned Specialties	.319	.031	.349	.033
2033	Canned F&V	.956	.080	1.036	.059
2034	Dehydrated F&V	.342	.024	.366	.087
2035	Pickles	.319	.021	.339	.043
2037	Frozen F&V	1.101	.093	1.194	.115
2038	Frozen Specialties	.783	.062	.844	.093
203	PRESERVED F&V	3.824	.309	4.133	
2041	Flour	.580	.072	.652	.092
2043	Cereal	.145	.024	.169	.014
2044	Rice	.232	.013	.245	.082
2045	Prepared Flour	.087	.008	.095	.032
2046	Corn	.927	.085	1.012	.182
2047	Pet Food	.203	.031	.234	.181
2048	Feeds	.666	.046	.712	.120
204	GRAIN	2.840	.278	3.118	
2051	Bread	.464	.062	.526	.032
2052	Cookies	.232	.024	.256	.025
205	BAKERY	.695	.085	.780	

---

[a] Before tax.

Table 57. 1984-1988 Food and Feed Phase-Out Costs as a Percentage of 1979 Estimated Cash Flow (Continued)

SIC	Industry	1984-1988 Phase-Out Cash Costs[a] (Millions of 1982 Dollars)			1983-1984 Cash Costs as a Percent of 1979 Estimated Internal Cash Flow
		Transformers	Capacitors	Total	
2061	Raw Cane	.145	.010	.156	.078
2062	Refining	.493	.029	.522	.121
2063	Beet	.464	.031	.495	.201
2065	Confections	.637	.057	.694	.200
2066	Chocolate	.174	.015	.190	.025
2067	Gum	.058	.005	.063	.026
206	SUGAR	1.971	.147	2.118	
2074	Cottonseed	.232	.019	.251	.138
2075	Soybean	.843	.067	.910	.276
2076	Vegetable	.058	.003	.061	.160
2077	Animal	--	--	--	--
2079	Shortening	.261	.024	.285	.048
207	FATS AND OILS	1.391	.111	1.502	
2082	Malt Beverages	.725	.091	.815	.041
2083	Malt	.174	.015	.190	.225
2084	Wines	.203	.015	.219	.057
2085	Distilled Liquors	.405	.034	.439	.042
2086	Soft Drinks	.898	.065	.963	.058
2087	Flavorings	.174	.013	.188	.018
208	BEVERAGES	2.579	.231	2.810	
2091	Canned Fish	.087	.008	.095	.026
2092	Frozen Fish	.319	.026	.344	.131
2095	Coffee	.203	.021	.224	.025
2098	Macaroni	.145	.013	.159	.063
2099	Other	.840	.080	.921	.049
209	MISCELLANEOUS	1.594	.147	1.741	
20	FOOD - TOTAL	24.890	2.217	27.107	
2873	Fertilizers, Nitrogenous	2.174	.188	2.362	.191
2874	Fertilizers, Phosphatic	1.304	.123	1.428	.181
2875	Fertilizer Mixing	.029	.003	.032	.026
2879	Pesticides & Other	.580	.041	.621	.041
287	AGRICULTURAL CHEMICALS - TOTAL	4.085	.355	4.440	
TOTAL		28.975	2.572	31.547	

SOURCE: Putnam, Hayes & Bartlett, Inc.

These cash costs can also be expressed as a percentage of estimated 1979 internal cash flow* as shown in the last column of Table 57. These percentages are generally quite small. The largest is 0.589 percent for SIC code 2021, butter. For one other category, the impact is between 0.3 and 0.4 percent of internal cash flow, five categories are between 0.2 and 0.3 percent, 14 categories are between 0.1 and 0.2 percent, and the remaining 28 categories are all less than 0.1 percent. Again, a large absolute impact (in dollars) does not necessarily imply a large proportional impact. Neither does a small absolute impact necessarily imply a small proportional impact.

Some of the capacitors and transformers posing an exposure risk to food or feed may be owned by electric utilities, in which case the utility industry and its customers will bear a portion of the burden of this equipment replacement program. In the extreme case where all of this equipment is owned by utilities, the net present value of costs would increase by $15.7 million and the cash and revenue impacts would increase by $31.6 million over and above the costs associated with the phase-out of nonsubstation outdoor PCB capacitors. These figures correspond to an 11 percent and a 6 percent increase in costs, respectively, and do not represent a material increase in the small impact on utilities and their customers.

---

* See PHB, 1980, p. 64. The comparison of 1982 dollars and 1979 dollars is again conservative, tending to overstate the impact.

REFERENCES

EEI. Edison Electric Institute. 1974. Historical statistics of the electric utility industry through 1970. New York: EEI.

EEI. Edison Electric Institute. 1978. Edison electric Institute year book of the electric utility industry. No. 45. Oct.

EEI. Edison Electric Institute. 1982. Comments and studies on the use of polychlorinated biphenyls in response to an order of the United States Court of Appeals for the District of Columbia Circuit. Washington, DC: EEI, 12 Feb.

EPRI. Electric Power Research Institute. 1978. Costs and benefits of over/under capacity in electric power system planning. EPRI EA-927. Palo Alto, CA: EPRI, Oct.

NEMA. National Electrical Manufacturers Association. Product statistical bulletin for capacitor section (8-CP), calendar years 1976-1981. Washington, D.C.

Personal communications. 1982. Mr. Robert G. Sheffler and Mr. George Newcomb, Capacitor Products Department, General Electric Company. July.

Personal communications. 1982. Mr. George Harakamper, New England Electrical System. July.

PHB. Putnam, Hayes & Bartlett, Inc. 1979. TSCA/PCB enforcement strategy. Washington, DC: EPA, 10 Dec.

PHB. Putnam, Hayes & Bartlett, Inc. 1980. The impact of additional regulation of polychlorinated biphenyls (PCBs) in food-related industries. Vol. I. Washington, DC: EPA, Office of Pesticides and Toxic Substances, 8 Dec.

Pittaway AR, Heiden EJ, O'Connor RS. 1981. A study of enclosed use of PCB in the chemical industry. Prepared for Chemical Manufacturers Association, Regulatory Research Service, Dec.

Rancourt LR. 1981. Capacitor protective schemes investigated by northeast utilities. Presented to EPRI PCB Seminar, Dallas, TX, 1-3 Dec.

Versar, Inc. 1976. PCBs in the United States: Industrial use and environmental distribution. NTIS PB 252-012/3WP. Springfield, VA: NTIS, Feb.

Versar, Inc. 1977. Microeconomic impacts of the proposed marking and disposal regulations for PCBs (EPA 560/67-77-013). NTIS PB 267-833/2WP. Springfield, VA: NTIS, April.

Versar, Inc. 1978. Microeconomic impacts of the proposed 'PCB Ban Regulations.' NTIS PB 281-881/3WP. Springfield, VA: NTIS, May.

PROCEDURE FOR ANALYSIS OF ALTERNATIVE NEW RULES REGULATING THE USE OF PCBS IN ELECTRICAL EQUIPMENT

APPENDIX A

GENERAL METHODOLOGY

Executive Order 12291 requires that the costs and benefits of new rules be assessed for every major rule, as defined in section 1.b. of the Order. While EPA does not think that this rule regulating the use of PCBs in electrical equipment is a major rule, an economic impact analysis has been prepared complying, to the extent possible, with the requirements of E.O. 12291. As explained in Chapter 3, the costs of each alternative rule were measured as the incremental social costs incurred to comply with the rule, including accelerated equipment replacement, PCB disposal, avoidance of spill clean-up, inspection, or any other costs that would otherwise be avoided or deferred if EPA were to authorize the use of PCBs in all electrical equipment indefinitely. Likewise, the benefits of each rule were measured by determining the expected weight of PCB spills or leaks that would be avoided by the rule. The expected PCB release avoided was used as a surrogate for a quantitative dollar measure of benefits, since a dollar increase could not be calculated with available time or data.

In order to facilitate the evaluation of many alternative rules, a major portion of the procedure for quantifying costs and benefits was automated. A computer model was designed to evaluate direct resource costs (e.g., accelerated equipment replacement, PCB disposal), as well as injury to health or the environment, measured by the expected PCBs released to the environment that would be avoided, for each alternative rule. Indirect costs were treated only qualitatively, or were estimated outside the model.

The EEI (1982) study of the use of PCBs in utility-owned electrical equipment presents a substantial amount of information regarding the quantity and type of PCB-containing electrical equipment still in use, as well as the costs required to replace, contain, inspect, or retrofill the equipment and to dispose of PCB material. Additional information describing the quantity and type of nonutility PCB-containing equipment, and the unit costs of various activities that might be required by the rule, have been obtained from reply comments to the 22 April 1982 Proposed Rule, from public documents, and through discussions with industry representatives. The objective of the computer model is to provide an adequate economic basis from which to compare alternatives by supplying the following information:

- An estimate of the age distribution of the current inventory of PCB-containing electrical equipment (required to estimate normal retirement rates as well as possible efficiency gains from replacing older equipment);

- A forecast of equipment retirement under various phase-out schedules, accounting for natural retirement or failure of equipment during the intervening period and accelerated phase-out by mandate;

- An estimate of the direct costs to society that result solely from the new rule (i.e., "incremental costs") for each year of use authorization, and the present value of those costs; and

- A forecast of the weight of PCBs spilled each year, and the amount requiring disposal each year, accounting for the decline in the in-service equipment population that results from failure, natural retirement, or mandated phase-out.

MODEL OUTPUT

A section of the computer code was devoted to each of the calculations described above. The following output was available from the model for each scenario. A single scenario considered one type of equipment with a given phase-out schedule and given assumptions regarding equipment characteristics and economic parameters. The following information is calculated for each year of the model simulation.

1. NEW (Y) - Number of new equipment units installed in year (Y), from 1944 to ENDYR
2. REBUILD (Y) - Number of equipment units rebuilt and reinstalled in year (Y), from 1944 to ENDYR
3. NEWFAIL (Y) - Number of equipment units never rebuilt which fail in year Y
4. REBFAIL (Y) - Number of rebuilt equipment units which fail in year Y
5. NEWRET (Y) - Number of equipment units never rebuilt which are retired in year Y
6. REBRET (Y) - Number of rebuilt equipment units which are retired in year Y
7. TOTNEW (Y) - End of year Y inventory of equipment never rebuilt
8. TOTREB (Y) - End of year Y inventory of equipment rebuilt once
9. PHASEOUT (Y) - Number of new and rebuilt units phased out by mandate in year Y, for each year of an accelerated replacement program

10. TOTAL (Y) -	Total end of year Y inventory of equipment in use, from 1944 to ENDYR
11. DISPOSE (Y) -	Reduction in inventory in year Y: units that must be permanently disposed due to retirement, failure, or phase-out, net of units rebuilt
12. TOTPHASE -	Total units phased out by mandate between 1982 and ENDYR
13. TSTOCKCOST (Y) -	Incremental nominal dollar costs in year Y which depend on the average number of units in service (e.g., inspection and maintenance), for years 1982 to ENDYR
14. TFLOWCOST (Y) -	Incremental nominal dollar one-time costs in year Y which depend on the number of units disposed (e.g., disposal costs, testing cost), for years 1982 to ENDYR
15. TRECURCOST (Y) -	The present value in year Y of a stream of costs beginning in year Y, depending on the number of units disposed in year Y (e.g., equipment replacement, removal, and installation), for years 1982 to ENDYR
16. TCLEANCOST (Y) -	Incremental nominal dollar out-of-pocket costs associated with each leak or spill in year Y (clean-up costs), for years 1982 to ENDYR

17. TOTALCOST (Y) -	The sum of TSTOCKCOST(Y), TFLOWCOST(Y), TRECURCOST(Y), TCLEANCOST(Y), and TSTORECOST(Y), for each year from 1982 to ENDYR
18. PVSTOCK, PVFLOW PVRECUR, PVCLEAN	The present value in 1982 of the stream of costs from 1982 to ENDYR defined by TSTOCKCOST(Y), TFLOWCOST(Y), TRECURCOST(Y), and TCLEANCOST (Y), respectively
19. PVCOST -	The present value of all incremental real resource costs associated with a given scenario, equal to the sum of PVSTOCK, PVFLOW, PVRECUR, and PVCLEAN
20. PCBRELEASE (Y) -	The expected weight of PCBs released from equipment spills in year Y, for years 1982 to ENDYR
21. CUMRELEASE (Y) -	The cumulative expected weight of PCBs released from equipment spills from 1982 through year Y, inclusive
22. PCBDISPOSE (Y) -	The weight of PCBs contained in equipment disposal in year Y, in pounds, from 1982 to ENDYR
23. CUMDISPOSE (Y) -	The cumulative weight in pounds of PCBs disposed from 1982 through year Y, inclusive

CALCULATION OF BENEFITS AND COSTS

For most cases, the calculations of the net social costs and the incremental PCB release avoided by an alternative rule proceeds directly from the output described above. The evaluation requires two computer runs: one for the base case (an indefinite authorization with no restriction), and one for the alternative. The calculations (performed outside of the model) are as follows:

(1) $\$\text{COSTS} = \text{PVCOST}_{\text{alternative}} - \text{PVCOST}_{\text{base case}}$

(2) INCREMENTAL PCB RELEASE AVOIDED (POUNDS) = $\text{CUMRELEASE (ENDYR)}_{\text{base case}}$

$- \text{CUMRELEASE (ENDYR)}_{\text{alternative}}$

As an indication of the severity of mandated phase-out, TOTPHASE, the sum of all PHASEOUT(Y) from 1982 to ENDYR, was also presented in the report (available directly from the model).

In five cases, additional one-time costs not accounted for in the model were calculated outside of the model:

1. For an indefinite authorization of PCB capacitors located in substations or restricted areas, with immediate (1982) containment and biweekly dike inspection:

   a. $CONTAINMENT COST =
   unit cost to contain and inspect * population of capacitors in 1982 + ΔPVSTOCK (inspection case scaled for number of capacitor banks diked and unit dike inspection cost)

   b. $COSTS =
   $\Delta\text{PVCLEAN}_{\text{Immediate Phase-Out}}$ + $CONTAINMENT COST

   Note: Containment was assumed to avoid all incremental clean-up costs, even though spills may still occur within the containment area. Since dike clean-up may still be required, this assumption tends to understate costs, in

   $\Delta\text{PVCLEAN}_{\text{immediate phase-out}}$

   is a negative quantity.

c. INCREMENTAL PCB RELEASE AVOIDED = 99% * INCREMENTAL PCB RELEASE $_{\text{Immediate Phase-Out}}$

2. For a 30-year phase-out of utility askarel transformers with immediate containment of all units in 1982 (assumed to avoid clean-up and transformer inspection but to require biweekly dike inspection):

   a. $CONTAINMENT COST =
      unit cost to contain * population of utility askarel transformers in 1982 + ΔPVSTOCK (inspection case scaled for biweekly dike inspection)

   b. $COSTS = ΔPVCLEAN$_{\text{immediate phase-out}}$ +
      $CONTAINMENT COST

   c. INCREMENTAL PCB RELEASE AVOIDED =
      99% Avoided PCB release (immediate phase-out)

3. For an indefinite authorization of utility askarel transformers with immediate retrofilling of all units in 1982 (assumed to avoid any inspection or clean-up costs but to require earlier disposal of askarel):

   a. $RETROFILL COST = incremental cost to retrofill all units with silicone and to purchase equipment and filters for continuous filtering

   b. $COSTS = ΔPVCLEAN (immediate phase-out)

      + $RETROFILL COST

      + ΔPVFLOW$_{\text{immediate phase-out}}$

   c. INCREMENTAL PCB RELEASE AVOIDED =
      99% * AVOIDED PCB RELEASE (immediate phase-out)

Similar calculations were performed to estimate retrofill costs for nonutility askarel transformers and askarel transformers posing an exposure risk to food or feed. Similar equations were also used to estimate breakeven containment costs for containment/retrofill indifference,

2. For a 30-year phase-out of utility askarel transformers with immediate containment of all units in 1982 (assumed to avoid clean-up and transformer inspection but to require biweekly dike inspection:

   a. $CONTAINMENT COST =
      unit cost to contain * population of utility askarel transformers in 1982 + ΔPVSTOCK (inspection case scaled for biweekly dike inspection)

   b. $COSTS = $\Delta PVCLEAN_{\text{immediate phase-out}}$ +
      $CONTAINMENT COST

   c. INCREMENTAL PCB RELEASE AVOIDED =
      99% Avoided PCB release (immediate phase-out)

3. For an indefinite authorization of utility askarel transformers with immediate retrofilling of all units in 1982 (assumed to avoid any inspection or clean-up costs but to require earlier disposal of askarel):

   a. $RETROFILL COST = incremental cost to retrofill all units with silicone and to purchase equipment and filters for continuous filtering

   b. $COSTS = ΔPVCLEAN (immediate phase-out)

      + $RETROFILL COST

      + $PVFLOW_{\text{immediate phase-out}}$

   c. INCREMENTAL PCB RELEASE AVOIDED =
      99% * AVOIDED PCB RELEASE (immediate phase-out)

Similar calculations were performed to estimate retrofill costs for nonutility askarel transformers and askarel transformers posing an exposure risk to food or feed. Similar equations were also used to estimate breakeven containment costs for containment/retrofill indifference, and to estimate the increase in removal/installation for phase-out/retrofill indifference.

and to estimate the increase in removal/installation cost for phase-out/retrofill indifference.

DESCRIPTION OF COMPUTER ALGORITHMS

1. Estimate Composition of Current Equipment Inventory

a. Assume that installation of new units began in 1944 and that total inventory in service grows in proportion to residential kWh sales for utilities until a specified end production year, ENDPDYR (input). Then:

TOTAL(Y) = TOTAL(Y-1)*SALESRATIO(Y)

b. Vary 1944 new installations ("seed" units) until 1981 in-service inventory matches target population in target year (e.g., EEI, 1982 estimate of 1981 in-service inventory).

TOTAL(TARGYR) = TARGPOP

c. Assume normal removal from service results from failure (a fixed percentage for every year) or from retirement (high early failure is ignored). The percentage retired varies by year for each vintage of equipment and is normally distributed around the mean equipment life. The percentages (normal probabilities) are calculated in the model based on the mean and standard deviation of the equipment life (input). Then:

NEW(Y) = TOTAL(Y) - TOTAL(Y-1) - REBUILD(Y) +
NEWRET(Y) + REBRET(Y) + NEWFAIL(Y) +
REBFAIL(Y)

d. Assumed proportions (input) of failed and retired units may be rebuilt each year, until an end rebuild year (input). If rebuilding is not technically feasible, the end rebuild year is set to 1944. Rebuilt units can have separate retirement characteristics. Then:

REBUILD(Y) = fraction of failed rebuilt *
NEWFAIL(Y) + fraction of retired rebuilt *
NEWRET(Y)

2. Forecast Retirements Under Phase-Out

a. Assume failure/retirement characteristics do not vary by equipment vintage.

b. For years after 1977 (end production year), assume that rebuilding results in total decontamination of unit, so that the unit is effectively retired from the population of PCB-containing equipment:

REBUILD(Y) = 0 for Y > 1977

c. For years after 1977, assume that no new units are added to the PCB-containing equipment population:

NEW(Y) = 0 for Y > 1977

d. Phase-out is "ramped" between two specified years (e.g., 1983, 1987), which designate the period over which accelerated replacement occurs. For each year after phase-out begins, a minimum fraction of units equal to the reciprocal of the remaining years of phase-out are replaced. The number of units phased out is determined as the additional units required to meet the minimum number replaced after accounting for normal retirement and failure. All units currently in service are assumed to require eventual replacement.

e. Phase-out units are removed randomly from the in-service inventory (i.e., the same fraction is removed from every vintage).

f. Forecast in-service inventory (end of year) and total units disposed (phase-outs plus failure and retirement) for every year until all units phased-out:

TOTAL(Y) = TOTAL(Y-1) - DISPOSE(Y)

DISPOSE(Y) = PHASEOUT(Y) + NEWRET(Y) +
NEWFAIL(Y) + REBRET(Y) + REBFAIL(Y)

g. Record cumulative units phased out to date:

TOTPHASE = TOTPHASE + PHASEOUT(Y)

h. The number of units stored for disposal is the cumulative excess disposed over disposal capacity, if any.

3. Estimate Costs

a. All annual costs are input as a unit cost per piece of equipment in 1982 dollars; total costs depend on the number of equipment pieces retired from service (disposed), the average number of pieces of equipment in service (mid-year), the number of spills or leaks, and the average number of units stored for disposal (mid-year).

b. TSTOCKCOST(Y) -- costs based on units in service, assuming average equipment size, location, and PCB concentration. Stock costs include: incremental inspection, maintenance, recordkeeping, and marking.

c. TFLOWCOST(Y) -- one-time costs associated with removal of equipment from service, including: disposal of equipment piece, PCB fluid disposal, and testing for identification of contaminated units.

d. TRECURCOST(Y) -- a stream of recurring costs beginning when equipment is taken out of service, occurring once every NEWLIFE years, where NEWLIFE is input. Recur costs include: removal of old equipment, installation of new equipment, purchase of new equipment, and purchase of rebuilt equipment. Costs are assumed to recur in perpetuity; the perpetuity factor (inverse of the real discount rate) is used to calculate the present value of the cost stream at the time of equipment removal/ replacement. Rebuilding costs are assumed to be 60 percent of the cost of a new unit (Versar, 1978), and are added to the unit recur cost as a present value.

TCLEANCOST(Y) = A stream of clean-up costs based on the unit cost to clean up a spill, the number of spills, the unit cost to clean up a leak and the number of leaks. Unit costs include all out-of-pocket costs for clean-up, including labor, ground removal, and waste incineration.

e. Unit stock, flow recur, and clean-up costs are inflated at separate rates (input). Total costs are discounted at the same rate (input), to calculate the present value of costs in 1982:

PVTOTAL = PVSTOCK + PVFLOW + PVRECUR + PVCLEAN

4. Estimate PCB Release and PCB Disposal

a. The expected annual PCB release due to spills is determined as the product of the number of units which fail each year, the fraction of failed units which spill, the average unit volume, the fluid density, the average PCB concentration, and the fraction of the unit volume spilled. The PCB release due to leaks similarly depends on the fraction of in-service units that leak, and the fraction of unit volume leaked.

```
PCBRELEASE(Y) =
  TOTAL(Y)*UNITVOL*DENSITY*PCBCONC*LKNFRATE
  *LKFRAC + FAIL(Y)*FFLSPILL*UNITVOL*DENSITY*
  PCBCONC*SPILLFRAC

where:   FAIL(Y) = FAILRATE * TOTAL(Y-1)
```

b. The expected annual weight of PCBs disposed each year is determined as the product of the number of units disposed each year, the average unit volume, fluid density, and PCB concentration. Only the number of units disposed varies by year:

```
PCBDISPOSE(Y) =
  DISPOSE(Y)*UNITVOL*DENSITY*PCBCONC
```

c. The cumulative PCB release and cumulative PCB disposal requirement are calculated as running totals each year.

MODEL INPUTS

1. Common Parameters

For each equipment category, a majority of the model inputs remained the same for all scenarios. These "constant" parameters are listed below.

a. PCB Capacitors (all groups, including: nonsubstation outdoor capacitors, capacitors located in substations or restricted areas, capacitors located indoors or in enclosed areas, and capacitors posing an exposure risk to food or feed):

$$\text{SALESRATIO}(Y) = \frac{\text{residential kWh sales, } Y}{\text{residential kWh sales, } Y-1}$$

where annual kWh sales were obtained from EEI Statistical Yearbooks of the Electric Utility Industry, for years 1945 to 1977.*

END REBUILD YEAR = 1944 (rebuilding not feasible)

END PRODUCTION YEAR = 1977 (based on industry comments)

FRACTION FAILED UNITS REBUILT = 0

FRACTION RETIRED UNITS REBUILT = 0

DENSITY = 11.6 pounds/gallon (EEI, 1982, p. A-14)

---

* For years 1945-1970: EEI (1974, p. 60); for years 1971-1977: EEI (1978, p. 31).

PCBCONC = 1.0 (EEI, 1982, p. A-14)

STOCKESC = .09 (escalation rate for stock costs, EEI, 1982, p. A-37)

FLOWESC = .09 (escalation rate for disposal costs, EEI, 1982, p. A-37)

RECESC = .09 (escalation rate for capital costs after first replacement, EEI, 1982, p. A-37)

SPILLESC = .09 (escalation rate for spill clean-up costs, PHB assumption)

LKESC = .09 (escalation rate for leak clean-up costs, PHB assumption)

LKFRAC = .01 (fraction of unit volume leaked per leak, PHB estimate based on utility survey spill data (EEI, 1982) and industry comments)

b. PCB Capacitors -- Constant parameters varying by group

1. Nonsubstation Outdoor Capacitors

TARGPOP = 1,232,272 (population of nonsubstation capacitors, EEI, 1982, p. 79-80)

TARGYR = 1981 (end of year applying to TARGPOP, EEI, 1982)

LKNFRATE = .75 percent per year (percentage of units which leak without failure, based on difference between moderate level and spill rate, EEI, 1982, pp. 79-80)

FFLSPILL = .485 (fraction of failures which spill, based on EEI, 1982 spill database and industry comments)

SPILLFRAC = .55 (fraction unit volume spilled per spill, based on EEI, 1982 spill database and industry comments)

LEAKCOST = 0.0 (unit cost in 1982 to clean up a leak, assumed to be negligible)

UNITVOL = 2.7 (gallons of contained fluid per unit, EEI, 1982, pp. 79-80)

2. Capacitors Located in Substations or Restricted Areas

TARGPOP = 1,568,347 (EEI, 1982, pp. 79-80)

TARGYR = 1981 (EEI, 1982)

LKNFRATE = .79 percent per year (based on difference between spill rate and moderate leak rate, EEI, 1982, pp. 79-80)

FFLSPILL = .083 (based on EEI, 1982 spill database and industry comments)

SPILLFRAC = .55 (based on EEI, 1982 spill database and industry comments)

LEAKCOST = 0.0 (assumed to be negligible)

UNITVOL = 2.7 (EEI, 1982, pp. 79-80)

3. Capacitors Located Indoors or in Enclosed Areas

TARGPOP = 489,654 (by difference, based on 1982 estimate of utility capacitors, EPA estimate of utility fraction of all capacitors and capacitors posing an exposure risk to food or feed)

TARGYR = 1981

LKNFRATE = .75 percent per year (by difference, using .8 percent moderate leak rate from EEI, 1982, pp. 79-80)

FFLSPILL = .25 (based on industry comments)

SPILLFRAC = .25 (based on industry comments and smaller unit volume)

LEAKCOST = 0.0 (assumed to be negligible)

UNITVOL = 2.0 (based on industry comments)

4. Capacitors Posing an Exposure Risk to Food and Feed

TARGPOP = 4,750 (based on EPA estimate that 10 percent of units used in food and feed industries pose an exposure risk and PHB, 1980 food and feed population estimate)

TARGYR = 1979 (PHB, 1980)

LKNFRATE = .78 percent per year (by difference, assuming .8 percent moderate leak rate from EEI, 1982, pp. 79-80)

FFLSPILL = .25 (based on industry comments)

SPILLFRAC = .25 (based on industry comments)

UNITVOL = 2.0 (based on industry comments)

LEAKCOST = 0.0 (assumed to be negligible if leaks solidify)

c. Askarel Transformers (for all groups, including utility-owned, nonutility-owned, and food or feed exposure risk transformers):

SALESRATIO(Y) = same as for PCB capacitors, 1945 to 1977

END REBUILD YEAR = 1975 (based on industry comments)

END PRODUCTION YEAR = 1977 (based on industry comments)

FRACTION FAILED UNITS REBUILT = .8 (PHB, 1978)

FRACTION RETIRED UNITS REBUILT = 1.0 (PHB, 1978)

DENSITY = 12.5 pounds/gallon (EEI, 1982, p. A-14)

PCBCONC = .7 (EEI, 1982, p. A-14)

STOCKESC = .09 (EEI, 1982, p. A-37)

FLOWESC = .09 (EEI, 1982, p. A-37)

RECESC = .09 (EEI, 1982, p. A-37)

SPILLESC = .09

LKESC = .09

LKFRAC = .005 (PHB estimate based on EEI, 1982 spill database and industry comments)

RECFRAC = .6 (fraction of cost of new transformer required to rebuild, Versar, 1978)

d. Askarel Transformers -- Parameters Varying by Group

1. Utility-Owned Askarel Transformers

TARGPOP = 39,640 (EEI, 1982, p. 60)

TARGYR = 1981

LKNFRATE = .72 percent per year (by difference between .8 percent moderate leak rate and spill rate, EEI, 1982, spill database)

FFLSPILL = 47.7 percent (based on average spill volume, EEI, 1982, and on industry comments)

SPILLFRAC = .25 (EEI, 1982 spill database)

UNITVOL = 215.07 (EEI, 1982, pp. 60, 62)

LEAKCOST = 0.0 (incremental cost assumed to be negligible)

2. Nonutility-Owned Askarel Transformers

TARGPOP = 91,597 (by difference, using EEI, 1982 utility population, EPA estimate of 30 percent utility ownership, and estimate of food or feed exposure risk units)

TARGYR = 1981

LKNFRATE = 1.5 percent (based on industry comments)

FFLSPILL = .45 (by similarity to utility costs and based on industry comments)

SPILLFRAC = .25 (based on utility data)

UNITVOL = 250 (based on industry comments)

LEAKCOST = 0.0 (incremental cost assumed to be negligible)

3. Askarel Transformers Posing an Exposure Risk to Food or Feed

TARGPOP = 958 (PHB, 1980 estimate of 1979 population used in food or feed industry, and EPA estimate that 10 percent pose an exposure risk)

TARGYR = 1979

LKNFRATE = .72 percent per year (based on industry comments)

FFLSPILL = 47.7 percent (by similarity to other transformers)

SPILLFRAC = .25 (based on utility data)

UNITVOL = 250 (based on industry comments)

LEAKCOST = 0.0 (incremental cost assumed to be negligible)

e. Utility-Owned Mineral Oil Transformers (data are stated per contaminated transformer)

SALESRATIO(Y) = same as for PCB capacitors, 1945 to 1977

END REBUILD YEAR = 1977

END PRODUCTION YEAR = 1977

FRACTION FAILED UNITS REBUILT = .8

FRACTION RETIRED UNITS REBUILT = 1.0

UNITVOL = 42.32 gallons per unit (EEI, 1982, p. 67)

DENSITY = 7.6 pounds/gallon (EEI, 1982, pp. A-14, A-15)

PCBCONC = 280 ppm (EEI, 1982, pp. 67, 69)

STOCKESC = .09 (EEI, 1982, p. A-37)

FLOWESC = .09 (EEI, 1982, p. A-37)

RECESC = .09 (EEI, 1982, p. A-37)

SPILLESC = .09

LKESC = .09

LEAKCOST = 0.0

TARGPOP = 2,386,077 mineral oil transformers containing $>$ 50 ppm PCB (EEI, 1982, p. 67)

TARGYR = 1981

LKNFRATE = .72 percent per year (assumed to be same as for askarel)

FFLSPILL = 47.7 percent (assumed to be same as for askarel)

SPILLFRAC = .25 (assumed to be same as for askarel)

LKFRAC = .005 (assumed to be same as for askarel)

RECFRAC = .6 (assumed to be same as for askarel)

2. Case-by-Case List of Variable Inputs

a. Input Definitions

BEGPHASEOT - Year in which equipment phase-out begins

ENDPHASEOT - Year in which equipment phase-out ends

STOCKCOST - Unit cost per equipment piece, stated in 1982 dollars, for costs depending on the units in service (e.g., inspection and maintenance)

FLOWCOST - Unit cost per equipment piece, stated in 1982 dollars, for one-time costs depending on the units disposed (e.g., disposal costs, testing costs)

RECBASE -	Unit cost per equipment piece, stated in 1982 dollars, representing the cost per occurrence of a stream of costs beginning in a given year and recurring periodically (e.g., equipment removal, installation and replacement)
MLF(NEW) -	The mean life in years for equipment that has never been rebuilt
SDLIFE(NEW) -	The standard deviation of the equipment life in years, for equipment that has never been rebuilt
MLF(REB) -	The mean life in years for equipment rebuilt once
SDLIFE(REB) -	The standard deviation of the equipment life in years, for equipment rebuilt once
NEWLIFE -	The period in years separating each occurrence of RECURCOST, generally the sum of MLF(NEW) and MLF(REBUILT)
RECLIFE -	The period in years after which a new unit is rebuilt, on average
SUPERESC -	The nominal rate of escalation in the capital cost of equipment (RECBASE), during the period of use authorization

DISCOUNT - The nominal rate of interest used to discount all costs to 1982

FAILRATE - The fraction of equipment units that fail each year

SPILLCOST - The clean-up cost in 1982 for a PCB spill, on average

b. Variable Input List:

Refer to Tables A-1 through A-8.

UNIT COST DERIVATION

(All costs and figures from EEI (1982) unless otherwise stated.)

1. Nonsubstation Outdoor PCB Capacitors

a. Stock Cost

0 for cases without inspection

$10/inspection/bank ÷ 7 capacitor/bank (includes transportation)	$1.43/capacitor/ inspection
Annual cost of quarterly inspection =	$5.71/capacitor

b. Recbase

Removal/Installation 4 mhrs @ $34/mhr =	$136.00
Replacement Equipment: $2.88/KVAR*100 KVAR -	$288.00
	$424/capacitor

c. Flow Cost

Labor: 1/2 hr @ $34/hr	$17.00
Disposal Cost	$50.00
Transportation Cost	$26.00
	$93.00/capacitor

2. PCB Capacitors Located in Substations or Restricted Areas

a. Stock Cost

0 for all cases without inspection

$20/hr * .86 less/ inspection/bank ÷ 30 capacitor/bank = (no incremental transportation included)	$0.57/capacitor/ inspection
Annual cost of quarterly inspection =	$2.29/capacitor

b. Recbase -- same as for nonsubstation outdoor capacitors.

c. Flow Cost -- same as for nonsubstation outdoor capacitors

d. Special Cases:

Cost to construct 20' x 20' dike = $5,080

$\$5080/\text{dike} * \frac{1\ \text{dike}}{\text{bank}} \div$ 30 capacitors/bank =	$169.33/capacitor
$169.33 * 1,568,347 capacitors =	$265.5 million

3. PCB Capacitors Located Indoors or in Enclosed Areas

a. Stock Cost -- same as for substation capacitors

b. Recbase

Removal/Installation 4 mhrs @ $34/mhr =	$136.00
Replacement Equipment $9.28/KVAR * 50 KVAR =	$464.00
	$600/capacitor

c. Flow Cost

Labor	$17.00
Disposal (smaller unit) 50 * 2.0/2.7 =	$37.00
Transport	$26.00
	$80.00/capacitor

4. PCB Capacitors Posing an Exposure Risk to Food or Feed

a. Stock Cost:

Assumed to be one-half of cost for substation capacitors (normal inspection practice assumed to be more frequent)

Annual cost of weekly inspection:	$15/capacitor

b. Recbase -- same as for indoor capacitors

c. Flow Cost -- same as for indoor capacitors

5. Utility-Owned Askarel Transformers

a. Stock Cost

0 for all cases without inspection

For each inspection: .5/hrs/inspection * $20/hr. = (includes transportation)	$10/transformer/ inspection
Annual Cost for quarterly inspection: (4 x $10) =	$40/transformer

b. Recbase

Removal/installation $495,750,600 ÷ 39,640 units =	$12,506
Replace $552,420,500 ÷ 39,640 units =	13,936
	$26,442/transformer

c. Flow Cost

Disposal Cost	$2,150
Drain/rinse/transport	2,110
	$4,260/transformer

d. Special Cases

$ Containment Cost

$1,050/transformer mounted on concrete * 19,820 transformers =	$ 20.8 million
$14,372/transformer not mounted on concrete * 19,820 transformers =	284.9 million
	$305.7 million

$ Retrofill Cost (based in part on Dow Corning comment; not including accelerated disposal costs)

Labor: 36 mhrs * $34/mhr	$1,224
Rinse Stock: 215 gal/transformer * 1 rinse * $3/gal	645
Retrofill fluid: 215 gal/transformer * 1 retrofill * $10/gal	2,150
Increased fire protection	1,000
Transportation	452
Equipment used to filter retrofill fluid; filters	11,000
	$16,471/transformer
TOTAL = 39,640 * $16,471 =	652.9 million

6. Nonutility Askarel Transformers

a. Stock Cost -- same as for utility-owned units

b. Recbase

Removal/Installation	$13,567/transformer
Replacement (1500 KVA average size)	$15,119
	$28,686/transformer

c. Flow Cost (250 gal contained fluid)

Disposal	$2,500
Drain/rinse/transport =	$2,233
	$4,733/transformer

d. Special Cases:

$Retrofill Cost (not including accelerated disposal costs)

Labor	$ 1,224
Rinse Stock 250 gal * $3/gal	750
Retrofill Fluid 250 gal * $10/gal	2,500
Increased fire protection	1,000
Transportation	452
Equipment for Filtering/ Filters	11,000
	$16,926/transformer
TOTAL = 91,597 * $16,926 =	$550.4 million

7. Askarel Transformers Posing an Exposure Risk to Food or Feed

a. Stock Cost -- same as for nonutility transformer

b. Recbase -- same as for nonutility transformer

c. Flow Cost -- same as for nonutility transformer

d. Special Cases

$Retrofill (not including accelerated disposal costs)

Unit cost same as nonutility units:	$16,926/transformer
TOTAL: 938 units (1982) * $16,926 =	$15.88 million

3. Mineral Oil Transformers

a. Stock Costs

0 except for cases with inspection

$10/transformer/ inspection

Cost per contaminated
transformer =
$\$10 * \frac{20{,}227{,}428}{2{,}386{,}077} =$ $84.77/contaminated transformer

b. Recur Costs

Removal/installation
$\$1{,}119 * 10^6 \div$
2,386,077 units = $ 469

Replacement $\$2{,}596 * 10^6$
÷ 2,386,077 units = 1,088

$1,557/unit

The $1,557 figure is then adjusted to account for the proportion of rebuild/replace and replace/rebuild perpetuities and for the discount rate and equipment lives for the case being analyzed.

c. Flow Costs

With common collection (2.5 times volume disposed as with testing of each equipment piece)

Disposal
42.32 gal/unit *
7.6 lbs/gal * $0.40/lb *
2.5 = 321.63

Drain
2 mhrs @ $34/mhr 68.00

Transport
42.32 gal/unit *
7.6 lbs/gal * $3/loaded mi
* 700 mi ÷ 50,000 lbs
* 2.5 = 33.75

Testing
$82/test*(20,227,428 units
÷ 25 units/test) ÷
2,386,077 units = 27.81

Total Unit Cost = $451.19

Without Common Collection:

Testing $303/test * 20,227,428 units ÷ 2,386,077 units =	$2,569
Disposal 4,232 gal/unit * 7.6 lbs/gal * $0.40/lb =	129
Drain 2 mhrs @ $34/mhr	68
Transport 42.32 gal/unit * 7.6 lbs/gal * $3/loaded mi * 700 mi ÷ 50,000/lbs =	13.50
Total Unit Cost =	$2,779.50

SOURCE OF OTHER INPUTS

1. DISCOUNT -- Estimate of discount rate, taken from EEI, 1982, pp. A-36, A-37 (.12 for all costs)

2. FAILRATE -- Equipment failure rate.

   Estimates were taken from industry comments (reported range from 0.1 percent to 0.4 percent) and assigned to categories based on fusing practices, susceptibility to lightning or power surges, maintenance practice, and the proportion of time a unit is energized. Values were cross-checked against reported spill frequencies, using an estimate of FFLSPILL, EEI, 1982 spill database, and other comments. Estimates for transformers were based on industry comments and Versar, 1978.

3. SPILLCOST -- Cost per spill for clean-up

   Estimates were based on industry comments and utility interviews (range: $100-$1,000,000). The cost was assumed to be insensitive to spill size, but to depend strongly on location.

4. SUPERESC -- Replacement cost escalation

A value of 9 percent was taken from EEI, 1982, pp. A-36, A-37. Phase-out programs were assumed not to cause abnormal price increases in base case runs.

5. Equipment Lives (MLF(NEW), SDLINE(NEW), MLF(REB), SDLIFE(REB), NEWLIFE, RECLIFE)

In general, capacitors were assumed to have 30-year lives, and transformers were assumed to have 60-year lives. Values are based on PHB, 1980 and industry comments. Since comments indicate a wide range of variation in equipment life, standard deviations of 40 percent (capacitors) to 30 percent (transformers) were assumed.

Table A-1. Variable Inputs to Computer Model for Nonsubstation Outdoor PCB Capacitors

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	EECBASE	HLF(NEW)/ SDLIFE(NEW)	HLF(REB)/ SDLIFE(REB)	NEWLIFE	REBLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
1	1982	1982	0.0	93	424	30/12	--	30	--	.09	.12	.004	6000
2	2030	2030											
3	1983	1987											
4	1983	1988											
5	1983	1992											
6	1983	1989											
7	1988	1997											
8	1993	2002											
9	1982	1982	5.7										
10			5.7										
11			5.7										
12			5.7										
13			5.7										
14	1982	1982	1.4										
15	1983	1987	1.4										
16	1983	1992	1.4										
17	1988	1997	1.4										
18	2030	2030	1.4										
19	1982	1982				25/10		25					
20	2030	2030				25/10		25					
21	1983	1987				25/10		25					
22	1983	1992				25/10		25					
23	1982	1982				40/16		40					
24	2030	2030				40/16		40					
25	1983	1987				40/16		40					
26	1983	1992				40/16		40					
27	1982	1982										.01	
28	2030	2030										.01	
29	1983	1987										.01	
30	1983	1992										.01	

Reproduced from best available copy.

Table A-1. Variable Inputs to Computer Model for Nonsubstation Outdoor PCB Capacitors (Continued)

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	RECBASE	HLF(NEW)/ SDLIFE(NEW)	HLF(REB)/ SDLIFE(REB)	NEWLIFE	REBLIFE	SUPPRESC	DISCOUNT	FAILRATE	SPILLCOST
31	1982	1982										.0015	
32	2030	2030										.0015	
33	1983	1987										.0015	
34	1983	1992										.0015	
35	1982	1982											1250
36	2030	2030											1250
37	1983	1987											1250
38	1983	1992											1250
39	1982	1982											30000
40	2030	2030											30000
41	1983	1987											30000
42	1983	1992											30000
43	1982	1992								.12			
44	2030	2030								.12			
45	1983	1987								.12			
46	1983	1992								.12			
47	1982	1982									.10		
48	2030	2030									.10		
49	1983	1987									.10		
50	1983	1992									.10		
51	1982	1982									.14		
52	2030	2030									.14		
53	1983	1987									.14		
54	1983	1992									.14		

Note: Values equal to value for RUN #1 unless otherwise stated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Table A-2. Variable Inputs to Computer Model for PCB Capacitors Located in Substations or Restricted Areas

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	RECBASE	MLF(NEW)/ SDLIFE(NEW)	MLF(REB)/ SDLIFE(REB)	NEWLIFE	REBLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
1	1982	1982	0.0	93	424	30/12	--	30	--	.09	.12	.001	250
2	2030	2030											
3	1983	1987											
4	1983	1992											
5	1993	2002											
6	2003	2012											
7	1982	1982	2.3										
8	2030	2030	2.3										
9	1983	1987	2.3										
10	1983	1992	2.3										
11	1993	2002	2.3										
12	2003	2012	2.3										

Note: Values equal to value for Run #1 unless otherwise indicated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Reproduced from best available copy.

Table A-3. Variable Inputs to Computer Model for PCB Capacitors Located Indoors or In Enclosed Areas

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	RECBASE	HLF(NEW)/ SDLIFE(NEW)	HLF(REB)/ SDLIFE(REB)	NEWLIFE	RECLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
1	1982	1982	0.0	80	600	30/12	--	30	--	.09	.12	.002	250
2	1983	1987											
3	1983	1992											
4	1988	1987											
5	1993	2002											
6	2030	2030											
7	1982	1982	2.3										
8	1983	1987	2.3										
9	1983	1992	2.3										
10	1988	1997	2.3										
11	1993	2002	2.3										
12	2030	2030	2.3										

Note: Values equal to value for Run #1 unless otherwise indicated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Table A-4. Variable Inputs to Computer Model for PCB Capacitors Posing an Exposure Risk to Food or Feed

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	RECCASE	MLF(NEW)/ SDLIFE(NEW)	MLF(REB)/ SDLIFE(REB)	NEWLIFE	RECLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
1	1982	1982	15.0	80	600	30/12	--	30	--	.09	.12	.001	5000
2	1983	1984											
3	1983	1985											
4	1983	1987											
5	1983	1988											
6	1983	1992											
7	2030	2030											
8	2030	2030	0.0										
9	1983	1984	0.0										
10	1983	1987	0.0										
11	2030	2030	1.15										
12	1983	1984	1.15										
13	1983	1987	1.15										
14	1984	1988	0.0										
15	1984	1988	15.0										

Note: Values equal to value for Run #1 unless otherwise indicated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Table A-5. Variable Inputs to Computer Model for Utility-Owned Askarel Transformers

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	RECBASE	MLF(NEW)/ SDLIFE(NEW)	MLF(REB)/ SDLIFE(REB)	NEWLIFE	RECLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
1	1982	1982	0.0	4260	26442	30/9	30/9	60	30	.09	.12	.002	6000
2	1983	1992											
3	1993	2002											
4	2003	2012											
5	2030	2030											
6	1982	1982	40.0										
7	1983	1992	40.0										
8	1993	2002	40.0										
9	2003	2012	40.0										
10	2030	2030	40.0										

Note: Values equal to value for Run #1 unless otherwise indicated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Reproduced from best available copy.

Table A-6. Variable Inputs to Computer Model for Nonutility-Owned Askarel Transformers

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	RECBASE	MLF(NEW)/ SDLIFE(NEW)	MLF(REB)/ SDLIFE(REB)	NEWLIFE	RECLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
1	1982	1982	0.0	4733	28686	30/9	30/9	60	30	.09	.12	.0025	6000
2	1983	1992											
3	1993	2002											
4	2003	2012											
5	2030	2030											
6	1982	1982	40.0										
7	1983	1992	40.0										
8	1993	2002	40.0										
9	2003	2012	40.0										
10	2030	2030	40.0										

Note: Values equal to value for Run #1 unless otherwise indicated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Table A-7. Variable Inputs to Computer Model for [illegible] Transformers [illegible] Exposure Risk to Food or Feed

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	REGBASE	MLF(BEM)/ SDLIFE(BEM)	MLF(REB)/ SDLIFE(REB)	NEWLIFE	RECLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
1	1982	1982	520.0	5733	23686	60/9	30/9	60	30	.09	.12	.002	6000
2	1983	1984											
3	1983	1985											
4	1983	1987											
5	1983	1988											
6	1983	1989											
7	1983	1992											
8	2030	2030											
9	1982	1982	0.0										
10	1983	1984	0.0										
11	1983	1985	0.0										
12	1983	1987	0.0										
13	1983	1988	0.0										
14	1983	1989	0.0										
15	1983	1992	0.0										
16	2030	2030	0.0										
17	1982	1982						40	24				
18	1983	1984						40	24				

Table A-7. Variable Inputs to Computer Model for Askarel Transformers Posing an Exposure Risk to Food or Feed (Continued)

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	RECBASE	HLF(NEW)/ SDLIFE(NEW)	HLF(REB)/ SDLIFE(REB)	NEWLIFE	RECLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
19	1983	1987						40	24				
20	2030	2030						40	24				
21	1982	1982						80	40				
22	1983	1984						80	40				
23	1983	1987						80	40				
24	2030	2030						80	40				
25	1982	1982										.005	
26	1983	1984										.005	
27	1983	1987										.005	
28	2030	2030										.005	
29	1982	1982										.0008	
30	1983	1984										.0008	
31	1983	1987										.0008	
32	2030	2030										.0008	
33	1982	1982											1250
34	1983	1984											1250
35	1983	1987											1250
36	2030	2030											1250
37	1982	1982											30000
38	1983	1984											30000
39	1983	1989											30000
40	2030	2030											30000
41	1982	1982								.12			
42	1983	1984								.12			

Reproduced from best available copy.

Table A-7. Variable Inputs to Computer Model for Askarel Transformers Posing an Exposure Risk to Food or Feed (Continued)

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	RECBASE	HLF(NEW)/ SDLIFE(NEW)	HLF(REB)/ SDLIFE(REB)	NEWLIFE	RECLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
43	1983	1987								.12			
44	2030	2030								.12			
45	1982	1982									.10		
46	1983	1984									.10		
47	1983	1987									.10		
48	2030	2030									.10		
49	1982	1982									.14		
50	1983	1984									.14		
51	1983	1987									.14		
52	2030	2030									.14		

Note: Values equal to value for Run #1 unless otherwise indicated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Table A-8. Variable Inputs to Computer Model for Utility Mineral Oil Transformers

RUN #	BEGPHASEOT	ENDPHASEOT	STOCKCOST	FLOWCOST	RECBASE	MLF(NEW)/ SDLIFE(NEW)	MLF(REB)/ SDLIFE(REB)	NEWLIFE	RECLIFE	SUPERESC	DISCOUNT	FAILRATE	SPILLCOST
1	1982	1982	0.0	2779.5	1507	30/9	30/9	60	30	.09	.12	.002	250
2	1983	1992			1525								
3	1993	2002			1540								
4	2003	2012			1550								
5	2030	2030		415.2	1557								
6	1982	1982	84.8		1507								
7	2030	2030	84.8	415.2	1557								
8	1993	2002	84.8		1540								

Note: Values equal to value for Run #1 unless otherwise indicated.

SOURCE: Putnam, Hayes & Bartlett, Inc.

Reproduced from
best available copy.